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TESTING CIVIL DEFENSE PLANS AND OPERATIONS AT THE FEDERAL, STATE AND LOCAL LEVELS

PREPARED FOR:

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF DEFENSE
WASHINGTON, D.C.

CONTRACT OCD-OS-62-60

FINAL REPORT

TESTING CIVIL DEFENSE PLANS AND OPERATIONS AT THE FEDERAL, STATE AND LOCAL LEVELS

Prepared for:

Office of Civil Defense
Department of Defense
Washington, D. C.

Contract OCD-OS-62-60

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OCD REVIEW NOTICE

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I. INTRODUCTION

A. Report Organization

The final report for Contract No. OCD-OS-62-60 is organized into three chapters. Chapter I is devoted to a brief discussion of the over-all problem studied during this contract. Chapter II presents descriptions of the three tests developed during the study, i. e., a Mustering Plan test, a Damage Assessment test, and a Radiation Analysis test. The final chapter presents the formulation of a system analysis of the civil defense organization designed to identify and quantify those functions with which Civil Defense should be concerned, and thus to provide a better basis for testing of plans.

B. The Problem

The contract for this study defined the problem as developing techniques for testing operational plans at the federal, state, and local levels of civil defense command. Detailed operational plans, under OCD policy which regards the fallout shelter as the principal means of protecting the civilian population had not as yet been developed at any of the three command levels. Therefore, the research effort of this study was first directed towards defining several functions of civil defense with the objective of developing techniques to test the accomplishment of functions. It was implicitly assumed that operational plans would be developed at a later date for each civil defense function. It became clear that in order to define all of the functions of civil defense and to determine the component activities of each function would require a much more elaborate analytical effort than had been anticipated. Hence, the problem was divided into two parts. Part one was concerned with developing techniques for testing certain broad functions whose operational responsibility was generally acknowledged to be that of civil defense organizations at each of the three levels of command. Part two of the problem was that of formulating an analysis of the civil defense system designed to provide a detailed definition and the logical justification of all the important functions of civil defense and the component activities associated with each function.

II. TESTS DEVELOPED DURING STUDY

This chapter consists of four parts. Part one contains a statement of the purpose and a brief description of each of the tests developed for the three broad civil defense functions of radiation analysis, mustering and damage assessment. The remaining three parts contain more detailed descriptions of each test. In addition, separate memoranda for each test have been submitted to the Office of Civil Defense. These separate memoranda contain additional information in the form of appendices which actually enable them to be employed as operational tests of appropriate control center operations.

A. Purpose and Brief Description of Radiation Analysis, Mustering, and Damage Assessment Tests

1. Radiation Monitoring System Test

a. Purpose of Test

The radiation monitoring test has a twofold purpose. One is to test the capability of control center radiation analysts to develop radiation contour maps and the second is to test the adequacy of the data gathering part of the system.

b. Description of the Test

Messages simulating the readings of radiation meters form the basic input for this test. The control center analysts are required to complete fallout contours based upon the hypothetical test data provided. The measure adopted for this test is the accuracy of the developed contour map as measured by the mean error between the true contours and the contours developed by the analysts and the precision of the developed map as measured by the mean deviation from the mean. Nomographs are provided to assist the test administrator to compute these measures. Among the features of the test are: (1) the testing of analytical capability of control center RADEF groups independent of the data collection system; (2) the testing of the adequacy of the data collection system; (3) the testing of analysis groups as individual entities or in consort with other RADEF groups; (4) the repeated use of the test without serious duplication of messages; (5) the introduction of some realism by using local place names of the radiation monitoring points, and (6) the introduction of meter errors and human error in the messages at the option of the test administrator.

2. Mustering Plan Test

a. Purpose of Test

The successful accomplishment of most if not all civil defense functions will depend upon groups of trained personnel reporting to preassigned positions in the event of a nuclear attack. The purpose of the mustering plan test is to estimate the percentage of the personnel in each group that are near enough to their assigned post to be actually available for duty.

b. Description of the Test Methodology

The mustering plan test methodology consists of a procedure for sampling the availability of members of a civil defense operating unit over time. A sample point consists of one member of a unit and a particular point in time. Time is divided into three periods: (1) weekends, (2) normal working hours, and (3) evening hours. Two sampling plans are used in this test. The first plan consists of a relatively large sample designed to estimate availability. The second plan requires a smaller sample and is used as a check to determine if the availability estimate remains valid at a later point in time. Sample sizes are presented in a form such that any knowledge of the probable availability is utilized to reduce the sampling workload. Detailed procedures for random sample selection and a model questionnaire are included as part of the test.

3. Damage Assessment Test

a. Purpose of Test

Damage assessment as it is performed by Civil Defense involves two distinctly different kinds of activities. First it is necessary to utilize many fragmentary reports received from communities in the vicinity of the nuclear explosion to estimate ground zero, burst height, and weapon yield. The task of estimating these quantities has been assigned to the state and regional civil defense command levels. The second kind of damage assessment activity involves transmitting ground zero, burst height, and yield information to a central data processing facility where computers are used to estimate the damage inflicted by each explosion. The purpose of the damage assessment test is to measure the ability of personnel at state and regional command levels to estimate weapon yield, ground zero, and burst height.

b. Description of the Test Methodology

The damage assessment test provides simulated messages to the attack analysis groups at state and regional control centers. Eight weapon yields are used in the test ranging from 120 kilotons to 34 megatons. Six of these weapons are taken as ground bursts and two are taken as air bursts. Damage profiles and simulated messages are provided as part of the test. The results of the test are expressed in terms of numerical values of weapon yield, burst height, and ground zero location. Among the features of the test are: (1) the test can be repetitively applied to the same group with no significant duplication of messages, (2) the test can be used to study individual control centers independently or groups of control centers in consort, (3) an element of realism is introduced into the messages by a technique permitting the use of local place names in the vicinity of the detonation, and (4) the test permits the overlapping of damage areas from two or more bombs.

B. Detailed Description of a Test for Measuring Radiological Analysis Capability at Local Civil Defense Centers

1. Introduction

This part of Chapter II presents test concepts and procedures which are applicable to radiological defense operations at all levels, and a discussion of a complete test package which can be used by Civil Defense personnel to measure radiological analysis capability at the local or county level.[1] (Similar packages for use at other levels can easily be generated using the one provided as a model.) It does not, however, contain standards of quality against which these measures of system performance may be compared. Until such standards are developed, it will be necessary to evaluate the capability of a given individual or organization by comparison with the performance of others or against subjective personal standards.

2. RADEF Functions

The function of RADEF operations is to "minimize the effect, on the people and resources of the United States, of nuclear radiation in the event of enemy attack and other major nuclear disasters."[2] It does this by (1) measuring the radiation levels at various locations and times; (2) analyzing this information in the control center to get the over-all picture; and (3) combining these analyses with a knowledge of radiological effects in order to provide operational briefings and technical guidance to the control center staff, and issue warnings and advisories to the public.

3. Test Concept

The most important thing about a RADEF organization is whether it does its job--that is, whether the operational briefings, technical guidance, public warnings and advisories, and the completed analyses it sends on to other RADEF organizations are of acceptable or unacceptable quality. But it is also important to know why the products are unacceptable, if that is

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[1] The tabular material (Tables 2-27) required for actual application of this test is contained in a separate Technical Memorandum, Testing Radiological Analysis Capability at the Local Level, submitted to the Office of Civil Defense March 15, 1963.

[2] Executive Office of the President, Office of Civil and Defense Mobilization. National Radiological Defense Plan. Annex 23, The National Plan for Civil Defense and Defense Mobilization.

the case, so that appropriate corrective action can be taken. For this reason, the test package provides for "diagnostic" as well as "end product" testing. Contour analyses, decay curves and fallout progression plots may first be evaluated to determine whether system performance is satisfactory. The source of unacceptable error in these products can then be determined by repeating the tests under conditions which isolate the several sources of error.

Error in the products can be caused by the design of the monitoring net, the monitoring instruments, the monitoring personnel, the communications system and/or the analyst who plots and analyzes the data. The tests described will discriminate monitoring net and analyst error under two conditions: where monitor and instrument error are not accounted for, and where random monitor and instrument error are present in the data.

Regardless of cause, however, all system errors are measured in terms of their effect upon the accuracy, precision, time-to-accomplish and legibility of the end products. The number and location of the monitoring stations, for example, are evaluated by performing a very careful analysis of simulated fallout data from the monitoring stations and comparing the result with an equally careful analysis based on complete data for the same area. Similarly, the error attributable to the analyst is measured by comparing his analysis of the complete data with the very carefully done analysis of the complete data. Total system error (combined analyst and monitoring net error) is measured by comparing the analyst's analysis of monitoring net data with the reference analysis.

4. Description of the Test

The test package contains fallout data based upon an assumed two megaton, 50% fission ground burst with an 8 mile per hour effective wind carrying the fallout generally east (see Figure 1). The data are presented for an area of approximately 100 square miles located about 30 miles downwind, purposely selected because of the wide range of values and gradients it contains.

The data are tabulated so that they can very rapidly be plotted on a grid with one-half mile intervals between lines. Tables are given for unit time reference dose rates, flash report times and for dose rates up through twelve hours after the attack. A nomograph (Figure 4) is provided for aid in calculating dose rates which are not tabulated. The original unit time reference dose rate contour analysis from which the tabulated data were derived is

shown in Figure 2. Figure 3 shows the pattern of fallout arrival in the area, and shows the over-all fallout pattern from which this local area pattern was taken.

In the application of the test, an analysis is conducted on the basis of some or all of the data and the analysis values for certain test points are compared with known values from the original data. The average error is calculated as a measure of accuracy; the average deviation as a measure of precision. Time-to-accomplish is taken into account by limiting it to realistic and reasonable values for the performance of each task, rather than by measuring it directly. Legibility is evaluated subjectively by the test officer as being either acceptable or unacceptable.

Different test procedures are employed for four distinct test cases: tests of the analyst alone using complete test data for a single point in time; tests of the analyst alone using complete test data for several points in time; tests of either the monitoring net alone or of the monitoring net and the analyst together, using partial test data for a single point in time; and tests of the monitoring net alone or of the monitoring net and the analyst together using partial test data for several points in time.

For each set of procedures, the test officer may elect to employ accurate or inaccurate data. The accurate data are derived directly from the Unit Time Reference Dose Rate Contour Analysis, Figure 1; the inaccurate data are these same values modified by a random error introduced to simulate meter errors and errors due to meter reading. The decision to use one or the other does not alter the appropriate test case procedure in any way, it being necessary only to consider the data used when interpreting the test results.

The reason for the several test cases, as mentioned before, is so that the test officer may diagnose the cause of unacceptable over-all performance. The reason for the optional use of inaccurate data is so that analyst and system performance can be evaluated under more realistic conditions where desired.

5. Test Procedures

a. Introduction: Preparation for the Test

Before the test can be used, it is necessary that the test officer acquire certain test materials and prepare others. These materials are:

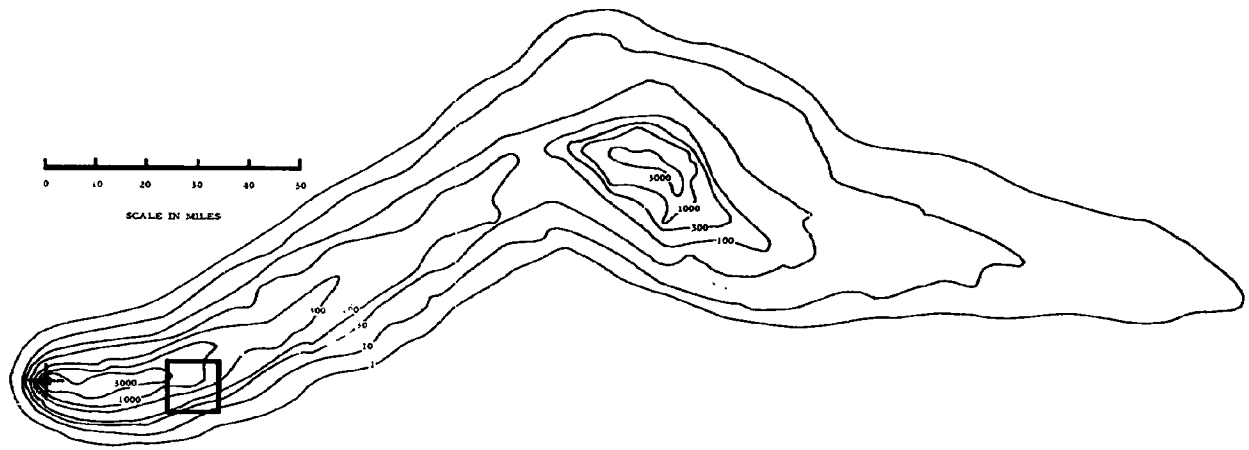
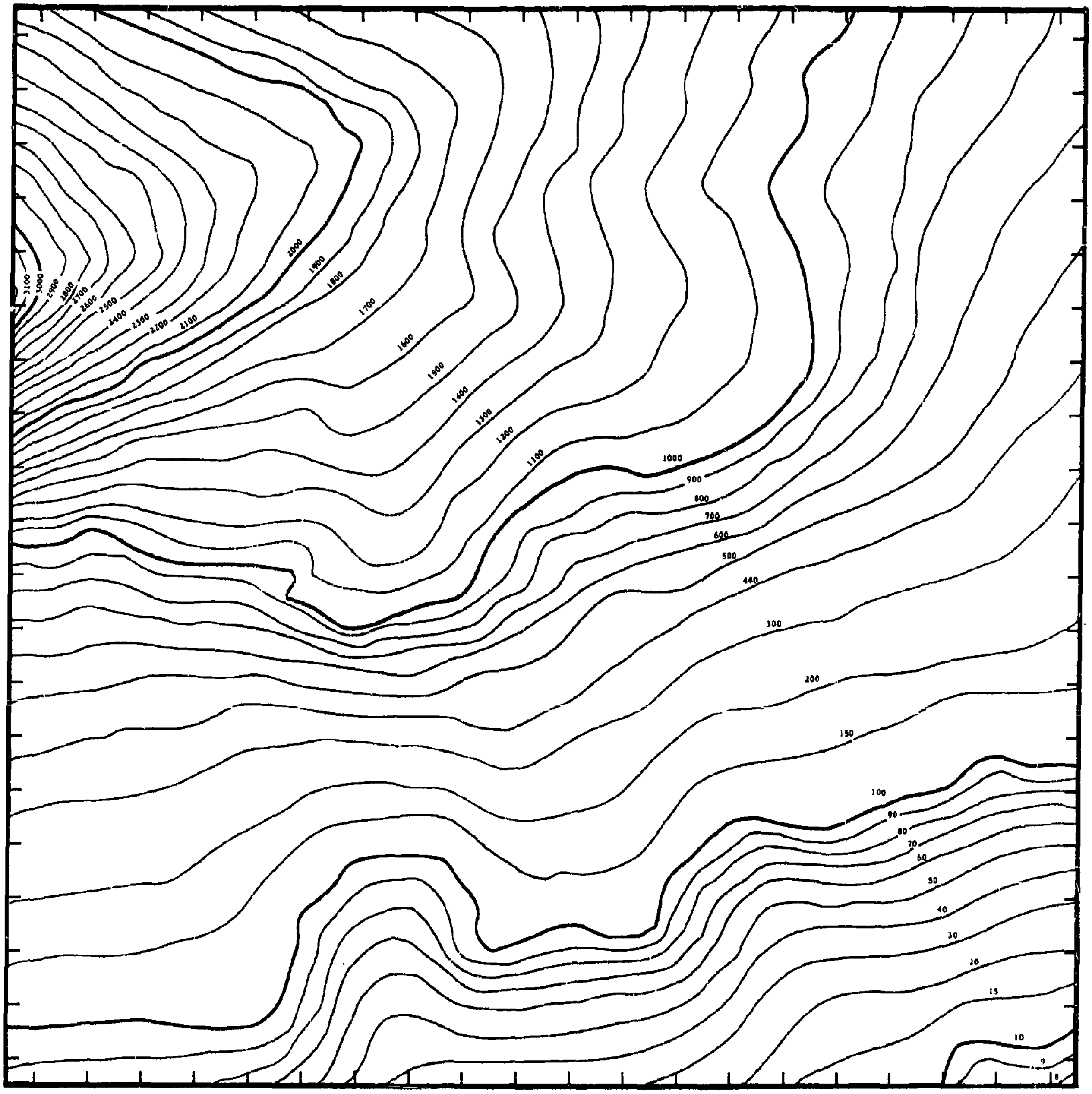
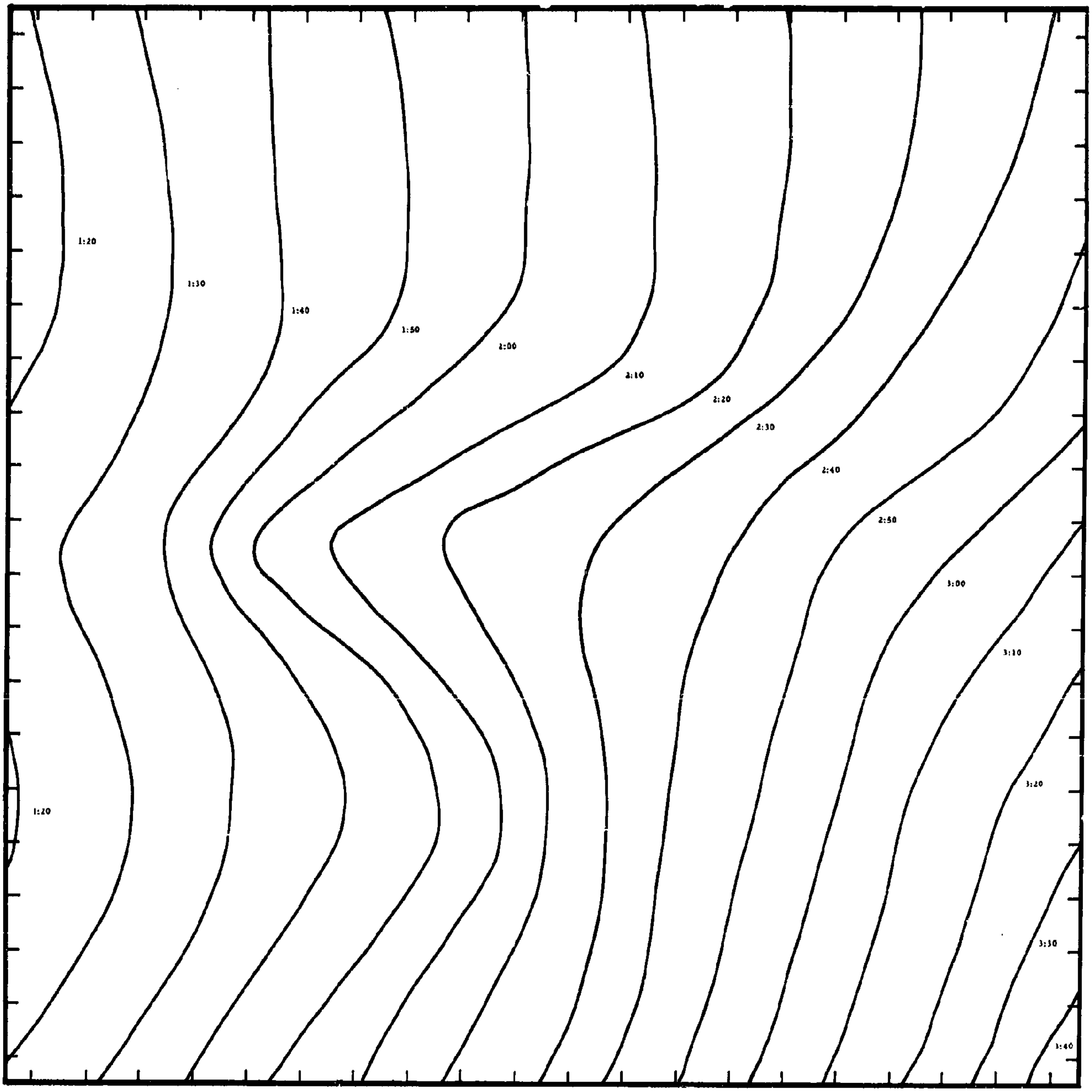


Figure 1. Original Complete Fallout Pattern
(Unit Time Reference Dose Rates)



SCALE: 1 GRID UNIT = 1/2 MILE

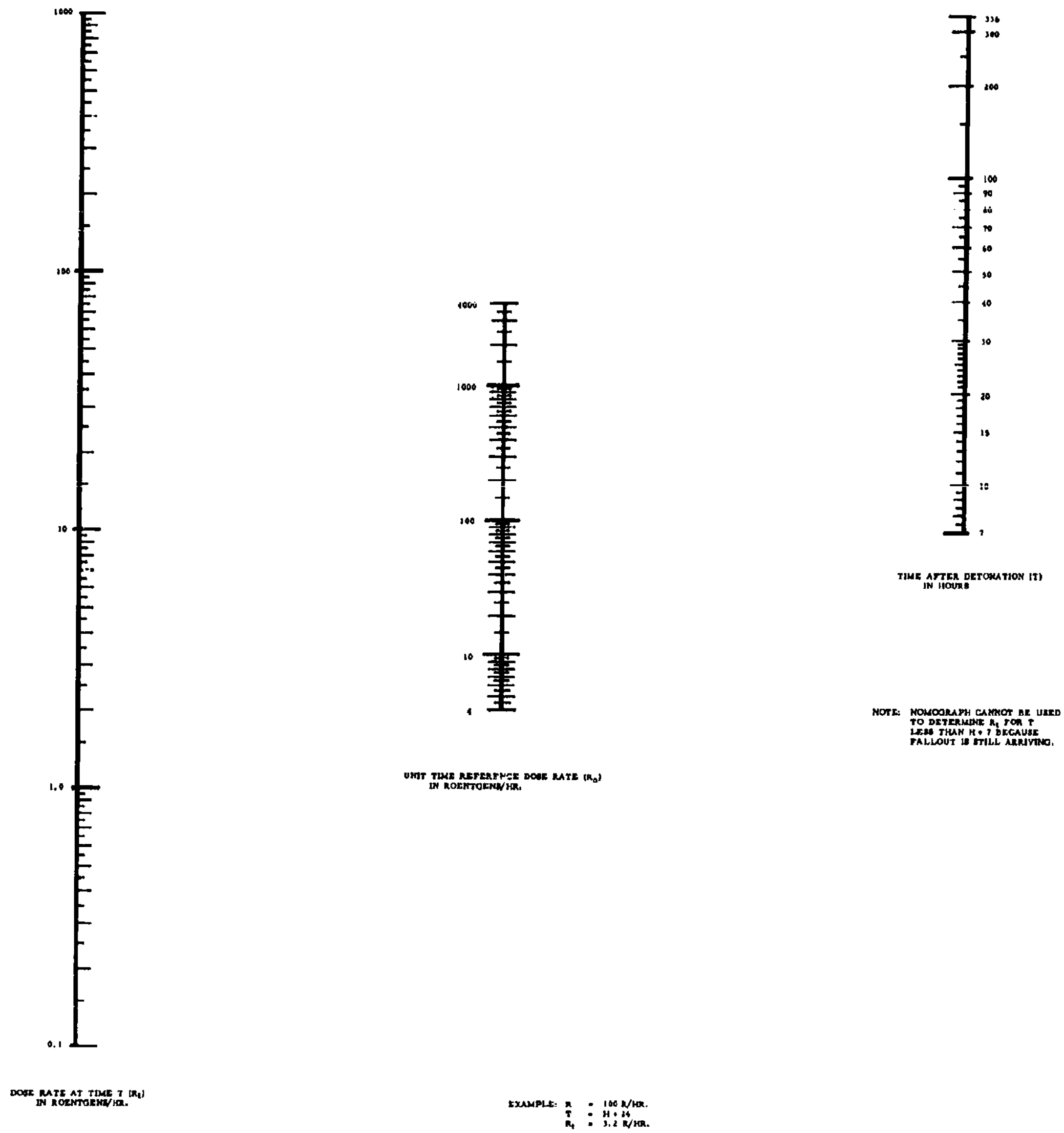
Figure 2. Unit Time Reference Dose Rate Contours



SCALE: 1 GRID UNIT = 1/2 MILE

Figure 3. Fallout Progression Analysis

Figure 4. Nomograph for Calculating Dose Rates Not Given in Tables



Clear plastic overlays (13), 20" x 20" minimum size
Grease pencils
Erasing cloth
12" ruler
Pencils
Paper, lined, letter size
3 x 5 cycle log-log graph paper
Map of local area
Completed 400 point data grids for accurate and inaccurate data
for H+2 to H+12 hours inclusive
Blank 400 point grid, to same scale as map
Flash report messages for accurate and inaccurate data

The time required to complete the test makes it impracticable to have the analyst plot his own dose rate data in Cases I and II from either the tables or from previously prepared realistic messages. The test officer, therefore, will have to arrange to have this done in advance of the test.

The data should be plotted on sheets of paper measuring at least 20 x 20 inches.[1] Centered on these sheets should be a grid of 400 points defined by the intersections of 20 vertical lines spaced 1" apart with 20 horizontal lines spaced 1" apart. The dose rates should be plotted, in the same positions as they appear in the tables, at the intersections of the lines. For convenience in referring to a particular location, the lines should be numbered from 1 to 20 starting at the left-hand top corner of the grid. A particular monitoring point is then referred to by giving first the number of the vertical line and then the number of the horizontal line running through it. For example, a point which is 14 lines from the left side and three lines from the top is referred to as "14, 3."

A blank 400 point grid is required for use in test cases III and IV. This grid may be drawn on transparent material (or directly on the map, if desired) to the same scale as the map of the local area which will be used in the test. Thus, the grid can be prepared in advance only if the scale of the map is known in advance. This grid is prepared in exactly the same way as the one above except that the distance between lines is a scaled 1/2 mile, and no dose rates or other data are plotted on it.

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[1] In preparing the data grids and the Flash Report messages, it is advisable to transform all tabulated times, which are given as time after bomb burst, to time after some arbitrary time of bomb burst. For example, assuming a bomb burst at 0800, H+2 becomes 1000, H+7 becomes 1500, etc.

Each of these grids, and the clear plastic overlays as well, should be indexed in opposite corners to make accurate alignment possible when one is laid on top of the other.

A separate test point grid need not be prepared unless specifically desired by the test officer. The 16 test points can quite easily be located directly on any 400 point grid by inspection.[1] For example, test point 1.5, 7.5 is located at the intersection of a vertical line midway between vertical lines 1 and 2 with a horizontal line midway between horizontal lines 7 and 8; that is, it lies precisely midway between grid point 1, 7 and 2, 8. The locations of and dose rate values for the 16 test points are given in Table 26 of a separate Technical Memorandum entitled "Testing Radiological Analysis Capability at the Local Level" submitted to the Office of Civil Defense, March 15, 1963.

Flash report messages must also be prepared in advance. These messages should be prepared in the following form:

25	0120	0101 Fallout
Day of Month	Time of Day	Monitoring Point Grid Coordinates

The messages should each contain flash reports covering a 15-minute period. The order of appearance of the individual reports in these messages is determined by the time of arrival of fallout; not by the location of that monitoring point relative to others in the grid.

On the following pages, the procedures to be employed in each test case are outlined and guidance is provided for interpreting test results. The selection of the test case to be used in each instance is left to the judgment of the responsible civil defense personnel.

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[1] Special care must be taken that the location of the test points is not marked on the material the analyst is using while conducting his analysis.

b. Case I: Test of Analyst in Static Situation

Materials:

Grid data for 400 points for any one time later than H+6[1]
Clear plastic overlay
Grease pencil
Erasing cloth
12" ruler

Procedure:

1) Provide analyst with all materials and read the following instructions to him:

"You have before you dose rate reports from 400 points in a monitoring network covering an area of 100 square miles. You will have 20 minutes in which to analyze these data by whatever means you desire, and in whatever degree of detail you please, using the clear plastic overlay and the grease pencil provided. The only restriction is that you may not copy down the readings for individual monitoring points.

"Be sure to keep the index marks on the clear plastic overlay aligned with the index marks on the grid while you work.

"At the end of 20 minutes, the data will be removed and you will be asked to read out, from your analysis, the values for 16 widely scattered test points. These test points will not be the same as any of the grid points for which you have been given data. It is suggested that you draw in the 1, 10, 30, 100, 300 and any other contour lines you feel are necessary in conducting your analysis. Consider the need for uniform coverage of the area as well as for careful work in your analysis."

2) At the end of 20 minutes, remove the grid data, mark on the clear plastic overlay the 16 test points, and instruct the analyst to determine as best he can the values for those points. At this point he may use any aids he wishes

[1] Data are tabulated in this package for times to H+12 inclusive; data for later times, if used, will have to be calculated using unit time reference dose rates and the nomograph in Figure 4.

and may work as slowly and carefully as he wishes. A reasonable time for him to accomplish this is 15 minutes.

3) Calculate the measures of error and interpret the results. [1]

c. <u>Case II: Test of Analyst in Dynamic Situation</u>

Materials:

Flash report summary message for H + 1:30, 1:45, 2:00, 2:15, 2:30, 2:45, 3:00, 3:15, 3:30, and 3:45[2]
Grid data for 400 points for H + 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12.
13 clear plastic overlays
3 x 5 cycle log-log paper
Grease pencil
12" ruler
Erasing cloth
Pencils
8-1/2 x 11" lined note paper

Procedure:

1) Make sure analyst has enough table and wall area to spread out the several grids for reference. Provide him with clear plastic overlays, log paper, grease pencil and erasing cloth. Read to him the following instructions:

> "Assume that a nuclear weapon, believed to be in the megaton range, has been detonated somewhere to the west of the area for which you will be receiving data. For the next several hours you will be receiving radiological fallout data from 400 monitoring points in an area of 100 square miles. These data will be given you at three to four times the normal rate; that is, you will receive data for a one-hour period in 15 to 20 minutes. Monitoring reports will be given you already plotted to save time.

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[1] Calculation of errors and interpretation of results are discussed separately under these headings on pages 26 through 40.

[2] See footnote, Page 11.

"You will be asked to perform several tasks using these data. You may perform these tasks in any manner you choose. The only restriction is that you may not copy onto your analyses the actual reported values for specific monitoring points. You will, however, be limited in the time you may take to perform each task. To aid you in using your time efficiently, you will be advised when there is one minute remaining in each time period. At the end of each period you will be asked to report your results for that period before going to the next period. You may keep these results for reference, but they will not be accepted by the test officer after you have received the data for the next period.

"As you work, be sure to keep the index marks on the plastic overlay aligned with those on the data grids, and keep in mind the need to reserve time for any additional tasks that might be assigned."

2) Provide analyst with data and tasks according to the schedule below. Data identification and task instructions, at the option of the test officer, may be read to the analyst or given him in message form. To make sure that the analyst does not lose track of his time and spend it all examining the data and none in preparing his report, inform him when there is one minute remaining in each time period. When only 15 seconds remain in the time period, ask him to report orally the values requested at the beginning of that period. Record these on the scoring sheet prepared for this purpose. Do not accept any reports after data for the next period have been given him.

Elapsed Time in Minutes	Data	Task Instructions
0	Flash reports through 0930[1]	"You have five minutes before the next flash report message will arrive in the Control Center. Estimate now, on the basis of the information you have, when fallout will arrive in the most distant areas of the grid and when fallout arrival will be complete throughout the grid."

[1]See footnote, Page 11.

Elapsed Time in Minutes	Data	Task Instructions
5	Flash reports from 0931 through 0945	"You have five minutes to update your estimates using these latest flash reports."
10	Flash reports from 0946 through 1000. Dose rate grid for 1000	"You have five minutes to update your estimates as above, and to estimate the maximum radiation level which will be reached anywhere in the area."
15	Flash reports from 1001 through 1015	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
20	Flash reports from 1016 through 1030	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
25	Flash reports from 1031 through 1045	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
30	Flash reports from 1046 through 1100. Dose rate grid for 1100	"You have five minutes to update your estimates of fallout arrival times and the maximum radiation level which will be reached anywhere in the grid."
35	Flash reports from 1101 through 1115	"You have five minutes to update your estimates of fallout arrival times using these latest flash reports."
40	Flash reports from 1116 through 1130	"You have five minutes to update your estimates of fallout arrival times using these latest flash reports."

Elapsed Time in Minutes	Data	Task Instructions
45	Flash reports from 1131 through 1145	"You have five minutes to update your estimates of fallout arrival times using these latest flash reports."
50	Dose rate grid for 1200	"Fallout is now arriving everywhere in the area. Continue to make your estimates of when fallout will be complete and, as soon as possible, estimate the fallout decay rate. Analyze and study the data in any manner you please. You will have 15 minutes to do this."
65	Dose rate grid for 1300	"Continue to analyze the data to determine when fallout will be complete and estimate decay rate if possible. You will have 15 minutes to do this."
80	Dose rate grid for 1400	"Continue to analyze the data to determine when fallout will be complete and estimate decay rate of possible. You will have 15 minutes to do this."
95	Dose rate grid for 1500	"You have 15 minutes to estimate the decay rate as accurately as you can at this time."
110	Dose rate grid for 1600	"You have 15 minutes to estimate, as accurately as you can at this time, the dose rates for locations 1, 19 and 19, 1 at 2000."

Elapsed Time in Minutes	Data	Task Instructions
125	Dose rate grid for 1700, 1800, 1900, 2000	"You have received all of the data that you will be given. You will now be given 90 minutes to perform a Unit Time Reference Dose Rate Contour Analysis, using the data and equipment you have available to you. At the end of 90 minutes, the data will be removed and you will be asked to read out, from your analysis, the values for 16 widely scattered test points. These test points will not be the same as any of the grid points for which you have been given data. It is suggested that you draw in the 1, 10, 30, 100, 300 and any other contour lines you feel are necessary in conducting your analysis. Consider the need for uniform coverage of the area as well as for careful work in your analysis."

3) At the end of 90 minutes, remove the grid data, mark on the clear plastic overlay the 16 test points, and instruct the analyst to determine as best he can the values for those points. At this point he may use any aids he wishes and may work as slowly and carefully as he wishes. A reasonable time for him to accomplish this is 15 minutes.

4) Compute measures of error for Contour Analysis and interpret results.

5) Compute measures of error of fallout progression estimates and future dose rate values; interpret results.

d. <u>Case III: List of Monitoring Network or of Monitoring Network and Analyst in Static Situation</u>[1]

Materials:

Tabulated dose rates for any one time <u>later than</u> H+6
Map of local area
Clear plastic overlay for map
Grease pencil
Erasing cloth
12" ruler
Pencils

Procedure:

1) Mark on the map the locations of the monitoring stations which report to the local Control Center. If desired, the number of stations may be reduced to simulate true emergency operating conditions.

2). Construct directly on the map a test data grid as described in the introduction to this section. The lines of the grid should be 1/2 mile apart, and the complete grid should be centered in an area 10 miles by 10 miles; but this scale may be varied slightly if necessary to make the grid cover an entire local area without significantly affecting the test results.

3). Mark the grid points nearest each of the monitoring stations in the monitoring network. These will be the points for which test data will be given.

4). Prepare a series of written dose rate messages for the points marked in Step 3. These messages should be in the following form:

> 0900 0110 390, which is interpreted: "at 0900 the dose rate at point 01, 10 was 390 roentgens per hour."

If desired, the local symbol for each monitoring station may be substituted for the grid coordinates. If this is done, the instructions read to the analyst must be appropriately reworded.

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[1] The procedure is identical in the two cases except for how and by whom the analyses are performed. In the former, the analyses are very carefully conducted by persons of known competence under the best possible conditions; in the latter, the system analyst performs the analyses under simulated operating conditions. The procedure is detailed for the first case only.

5.) Provide analyst with all materials and read the following instructions to him:

> "You have before you a map of your local area showing the locations of the monitoring points which report into the control center at which you are working. Also shown on this map is a grid of 400 points. The point nearest each monitoring station has been clearly marked. You are to plot all data you receive at these points, not at the actual monitoring points.
>
> "Monitoring reports have been given you for each of these monitoring points for one point in time. These messages will be in the form 0900 0110 390, which is read, "at 0900 the dose rate at 01, 10 was 390 roentgens per hour." You will have 20 minutes in which to analyze these data by whatever means you desire and in whatever degree of detail you please, using the clear plastic overlay and the grease pencil provided. Be sure to mark both the overlay and the map in some way so that the overlay can be accurately repositioned on the map if it is moved for any reason.
>
> "At the end of 20 minutes, the data will be removed and you will be asked to read out, from your analysis, the values for 16 widely scattered test points. These test points will not be the same as any of the grid points for which you have been given data. It is suggested that you draw in the 1, 10, 30, 100, 300 and any other contour lines you feel are necessary in conducting your analysis. Consider the need for uniform coverage of the area as well as for careful work in your analysis."

6.) At the end of 20 minutes, instruct the analyst to stop work and identify for him the 16 test points. Instruct him to determine as best he can the values for those points. At this point he may use any aids he wishes and may work as slowly and carefully as he wishes. A reasonable time for him to accomplish this is 15 minutes.

7.) Calculate the measures of error and interpret the results.

e. <u>Case IV: Test of Monitoring Network or of Monitoring Network and Analyst in Dynamic Situation</u>

Materials:

Tabulated dose rates and fallout arrival times through H+12[1]
13 clear plastic overlays
3 x 5 cycle log-log paper
Grease pencil
12" ruler
Erasing cloth
Pencils
8-1/2 x 11" lined note paper

Procedure:

1) Mark on the map the locations of the monitoring stations which report to the local Control Center. If desired, the number of stations may be reduced to simulate true emergency conditions.

2) Construct directly on the map a test data grid as described in the introduction to this section. The lines of the grid should be 1/2 mile apart, and the complete grid should be centered in an area 10 miles by 10 miles; but this scale may be varied slightly if necessary to make the grid cover an entire local area without significantly affecting the test results.

3) Mark the grid points nearest each of the monitoring stations in the monitoring network. These will be the points for which test data will be given.

4) Prepare a series of written dose rate messages for the points marked in Step 3. These messages should be in the following form:

> 0900 0110 390, which is interpreted, "at 0900 the dose rate at point 01, 10 was 390 roentgens per hour."

If desired, the local symbol for each monitoring station may be substituted for the grid coordinates. If this is done, the instructions read to the analyst must be appropriately reworded.

---

[1]See footnote, Page 11

5) Provide analyst with clear plastic overlays, log paper, grease pencil and erasing cloth. Read to him the following instructions:

> "You have before you a map of your local area showing the locations of the monitoring points which report into the control center at which you are working. Also shown on this map is a grid of 400 points. The point nearest each monitoring station has been clearly marked. You are to plot all data you receive at these points, <u>not at the actual monitoring points.</u>
>
> "Assume that a nuclear weapon, believed to be in the megaton range, has been detonated somewhere to the west of this local area. For the next several hours you will be receiving radiological fallout data from the grid points nearest the monitoring stations in the local net. Flash reports will be in the form 250120 0101 Fallout, which is read "at 0120 on the 25th, fallout was detected at 01, 01. The monitoring reports will be in the form 0900 0110 390, which is read "at 0900 the dose rate at 01, 10 was 390 roentgens per hour." You will be instructed to perform several tasks using these data. You may perform these tasks in any manner you choose, but you will be limited in the time you may take to do so. As you work, be sure to keep the index marks on the plastic overlay aligned with those on the data grids, and keep in mind the need to reserve time for any additional tasks that might be assigned."

6) Provide analyst with data and tasks according to the following schedule:

Elapsed Time in Minutes	Data	Task Instructions
0	Flash reports through 0930[1]	"You have five minutes before the next flash report message will arrive in the Control Center. Estimate now, on the basis of the information you have, when fallout will arrive in the most distant areas of the grid and when fallout arrival will be complete throughout the grid."

[1]See footnote, Page11.

Elapsed Time in Minutes	Data	Task Instructions
5	Flash reports from 0931 through 0945	"You have five minutes to update your estimates using these latest flash reports."
10	Flash reports from 0946 through 1000. Dose rate grid for 1000	"You have five minutes to update your estimates as above, and to estimate the maximum radiation level which will be reached anywhere in the area."
15	Flash reports from 1001 through 1015	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
20	Flash reports from 1016 through 1030	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
25	Flash reports from 1031 through 1045	"You have five minutes to update your estimates of fallout arrival times as above, using these latest flash reports."
30	Flash reports from 1046 through 1100. Dose rate grid for 1100	You have five minutes to update your estimates of fallout arrival times and the maximum radiation level which will be reached anywhere in the grid."
35	Flash reports from 1101 through 1115	You have five minutes to update your estimates of fallout arrival times using these latest flash reports."

Elapsed Time in Minutes	Data	Task Instructions
40	Flash reports from 1116 through 1130	"You have five minutes to update your estimates of fallout arrival times using these latest flash reports."
45	Flash reports from 1131 through 1145	"You have five minutes to update your estimates of fallout arrival times using these latest flash reports."
50	Dose rate grid for 1200	"Fallout is now arriving everywhere in the area. Continue to make your estimates of when fallout will be complete and, as soon as possible, estimate the fallout decay rate. Analyze and study the data in any manner you please. You will have 15 minutes to do this."
65	Dose rate grid for 1300	"Continue to analyze the data to determine when fallout will be complete and estimate decay rate if possible. You will have 15 minutes to do this."
80	Dose rate grid for 1400	"Continue to analyze the data to determine when fallout will be complete and estimate decay rate if possible. You will have 15 minutes to do this."
95	Dose rate grid for 1500	"You have 15 minutes to estimate the decay rate as accurately as you can at this time.
110	Dose rate grid for 1600	"You have 15 minutes to estimate, as accurately as you can at this time, the dose rates for locations 1, 19 and 19, 1 at 2000."

Elapsed Time in Minutes	Data	Task Instructions
125	Dose rate grid for 1700, 1800, 1900, 2000	"You have received all of the data that you will be given. You will now be given 90 minutes to perform a Unit Time Reference Dose Rate Contour Analysis, using the data and equipment you have available to you. At the end of 90 minutes, the data will be removed and you will be asked to read out, from your analysis, the values for 16 widely scattered test points. These test points will not be the same as any of the grid points for which you have been given data. It is suggested that you draw in the 1, 10, 30, 100, 300 and any other contour lines you feel are necessary in conducting your analysis. Consider the need for uniform coverage of the area as well as for careful work in your analysis."

7) At the end of 90 minutes, remove the grid data, mark on the clear plastic overlay the 16 test points, and instruct the analyst to determine as best he can the values for those points. At this point he may use any aids he wishes and may work as slowly and carefully as he wishes. A reasonable time for him to accomplish this is 15 minutes.

8) Compute measures of error for Contour Analysis and interpret results.

9) Compute measures of error of fallout progression estimates and future dose rate values; interpret results.

6. Calculation of Measures of Error[1]

The percent error is calculated for all numerical predictions and estimates. It is given by:

$$e_i = 100 \frac{V_a - V_t}{V_t}$$

where:

V_a is the value determined by the analysis, and

V_t is the true value as given in the table of true values (Table 26)

This percent error can be calculated by hand, or can be determined by employing the nomograph in Figure 5.

For contour analyses, 16 values of error can be used to calculate the mean error, using the formula:

$$E = \frac{1}{16} \sum_{i=1}^{16} e_i = \frac{e_1 + e_2 + \ldots + e_i + \ldots + e_{16}}{16}$$

where:

E is the mean error

e_i is i^{th} calculated percent error

and the mean deviation can be calculated by using the formula:

$$D = \frac{1}{16} \sum_{i=1}^{16} \left| E - e_i \right| = \frac{1}{16} \left[\left| E - e_1 \right| + \left| E - e_2 \right| + \ldots + \left| E - e_{16} \right| \right]$$

where:

D is the mean deviation

$|E-e_i|$ is the absolute (positive) value of the difference between the mean error and the i^{th} calculated percent error.

[1] These measures, and 16 as the number of test points, were selected primarily for ease of computation. No claim is made regarding their theoretical statistical validity.

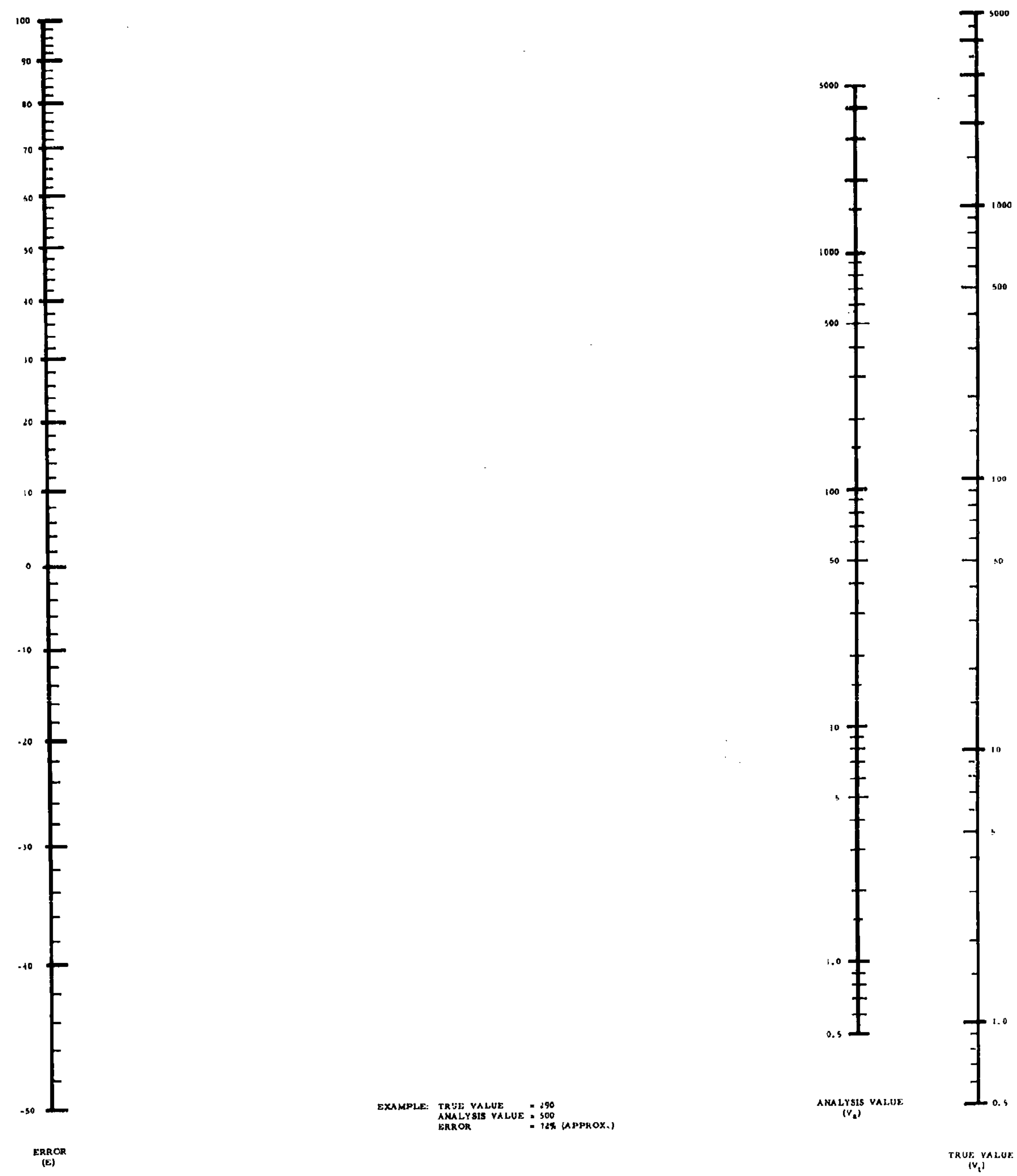


Figure 5. Nomograph For Calculating Percent Error

Example:

Analysis Value V_a	True Value V_t	Percent Error e_i	Percent Deviation $d_i = \lvert E - e_i \rvert$
79	87	-9.2	8.6
43	43	0	.6
65	73	-11.0	10.4
9	10	-10.0	9.2
104	97	6.7	7.3
302	290	4.1	4.7
564	525	7.4	8.0
725	735	-1.4	0.8
450	455	-1.1	0.5
275	285	-3.5	2.9
102	90	13.3	13.9
95	90	5.6	6.2
85	85	0	.6
85	87	-2.3	1.7
65	72	-9.7	9.1
110	108	1.9	2.5
		$\Sigma e_i = -9.2$	$\Sigma d_i = 87$
		$E = -.6$	$D = 5.4$

7. Interpretation of Results

a. Meaning and Usefulness of Measures

The percent errors calculated for the numerical predictions and estimates are readily understood as measures of performance. Accuracy and precision, on the other hand, require some explanation.

The mean error is a measure of accuracy; the mean deviation a measure of precision. The former measures the extent to which an analysis contour is displaced from the true contour; the latter the extent to which the analysis contour is dissimilar in shape from the true contour.

To visualize the distinction between these two measures, imagine an analysis contour line superimposed upon a true contour line for comparative purposes. If the analysis contour seems to be on one side of the true contour about as much as on the other, it is an accurate approximation of the true one; but because of its different shape, not a precise one. If, in addition to being different in shape, it is displaced so that a good fraction of the time it is off to one side of the true line, it is inaccurate as well as imprecise. (See Figures 6A and 6B.)

On the other hand, imagine an analysis contour which is very nearly identical to the true contour. If that contour is superimposed directly on the true contour, it is precise as well as accurate. If it is located on one side or the other of the true contour, it is precise, but inaccurate. (See Figures 6C and 6D.)

Accuracy and precision are important measures because they relate to the amount of overexposure to radiation and to time lost due to operational decisions based on the analysis. Time-to-accomplish is important because the analyst must be capable of performing the analysis within time limits imposed by the operational system. Legibility is important because of its relationship to the usefulness of the analysis, the time which might be wasted trying to read it, and the errors which might result from misreading it.

b. Evaluation of Results

At this time no objective standards exist for judging the worth of a particular set of values of these measures. Until such standards are published, it will be necessary for responsible civil defense personnel to evaluate the results of this test by comparison with whatever standards seem most appropriate to them at the time. Three specific, operationally useful, alternatives are recommended.

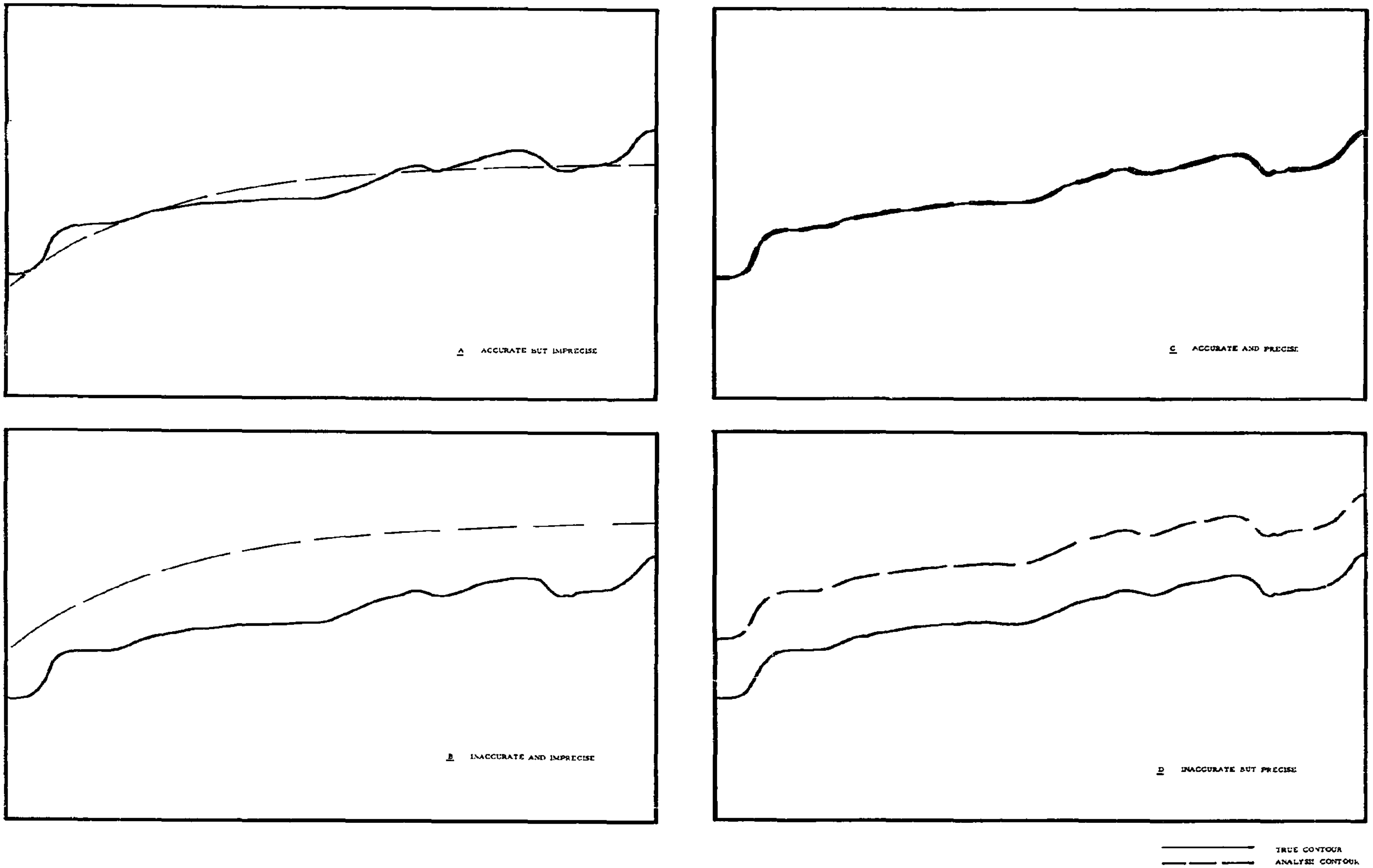


Figure 6. Accuracy and Precision Illustrated

First, the results of a test may be compared with the results obtained by an analyst, or a system, of known competence. If a particular community is generally acknowledged to be well prepared in RADEF operations, then a knowledge of one's standing relative to that community can be of value in judging whether his state of readiness is adequate or inadequate.

Alternatively, one can compare his results with the measures of accuracy and precision for the several analyses illustrated in this test package. In doing this, it is necessary that he first determine which of the analyses is, in his judgment, acceptable. It is also necessary that he make independent judgments regarding the legibility and time-to-accomplish of his analyses.

Finally, he can relate varying degrees of the measures to differences in exposures and lost time, and decide what amounts of these are acceptable and what amounts are unacceptable. As in the second alternative, independent judgments must be made regarding legibility and time-to-accomplish.

Whatever basis for comparison is employed, the RADEF System Evaluation Scoring Sheet, Figure 12, will be found useful in making that comparison and evaluation more systematic. The scoring sheet will be found particularly useful in noting the number of estimates made and the pattern of improvement as more data are received, for it is particularly important for the test officer to avoid the tendency to downgrade an analyst for large errors in early estimates which others don't even attempt.

As an aid in the evaluation of analyses, Figures 7 through 11 are presented on the following pages. But first a word about the confidence to be placed in the results of test calculations.

The measures of accuracy and precision are obtained by sampling the error at 16 points in the grid and using those values as estimates of the over-all error in the analysis. With such a small sample, and without knowledge of the actual distribution of all the errors, it is possible to make only very general statements about the accuracy and precision of one analysis relative to another. The smaller the mean deviation, however, the more likely it is that the differences indicated between two analyses really exist, and the better the estimates of accuracy and precision really are. Generally speaking, it is not wise to place much confidence in differences where the estimates of precision are significantly larger than the differences.

For example, consider the measures of accuracy for the 400-point accurate and inaccurate data analyses (see Table 1). Little confidence should

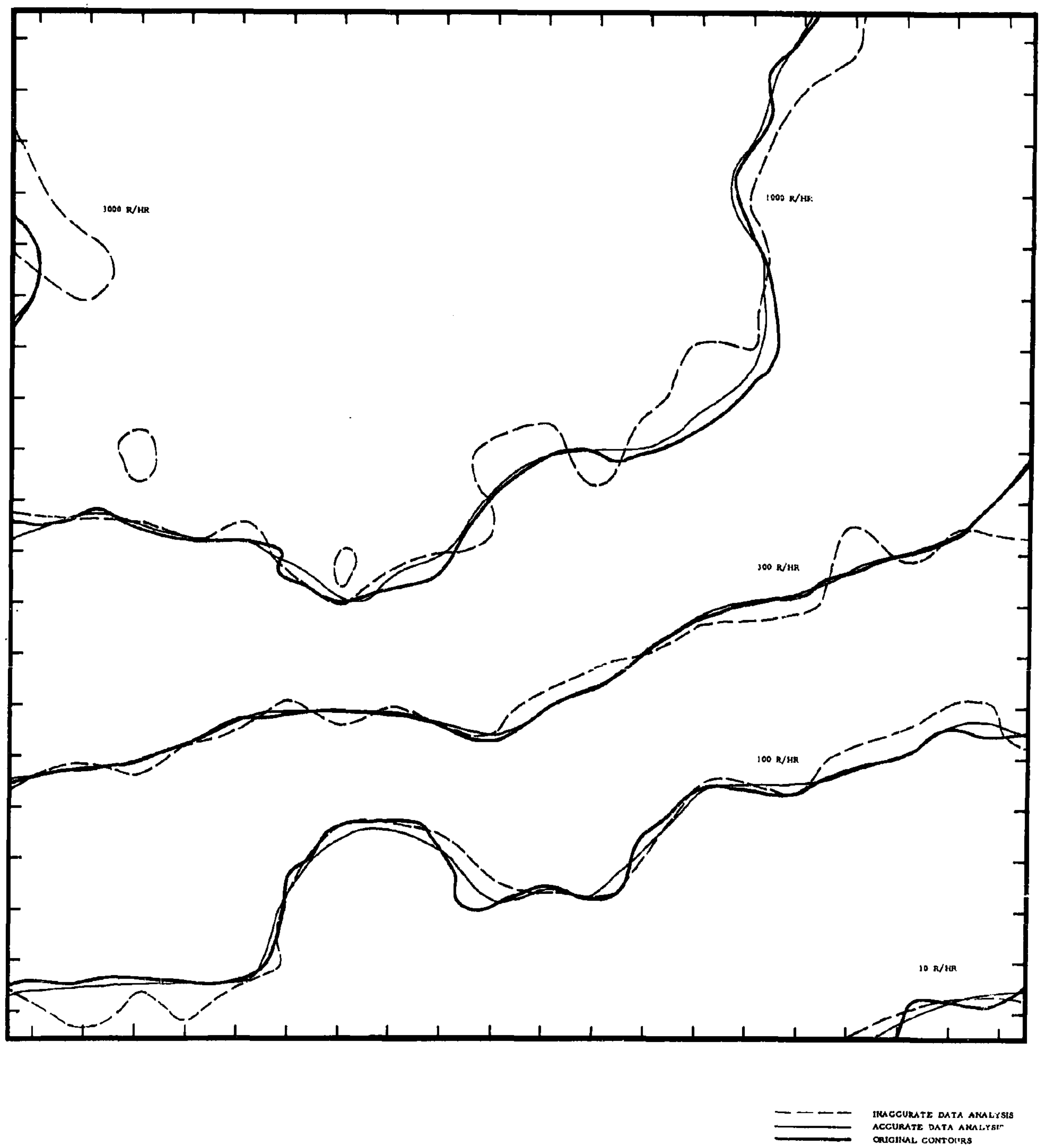


Figure 7. Comparison of Original Fallout Contours With Analyses Based on Accurate and Inaccurate Data from 400 Grid Points

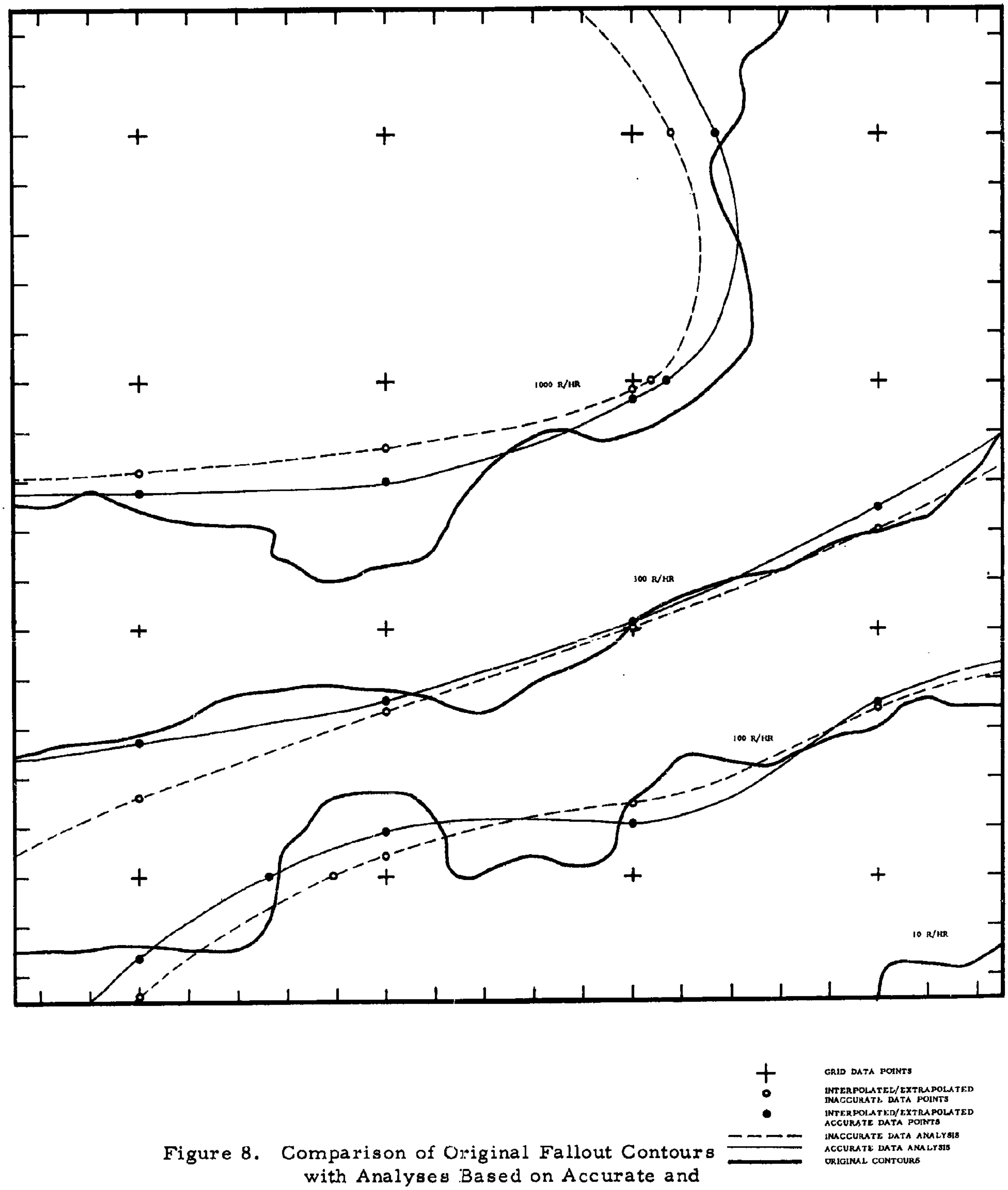


Figure 8. Comparison of Original Fallout Contours with Analyses Based on Accurate and Inaccurate Data from 16 Grid Points

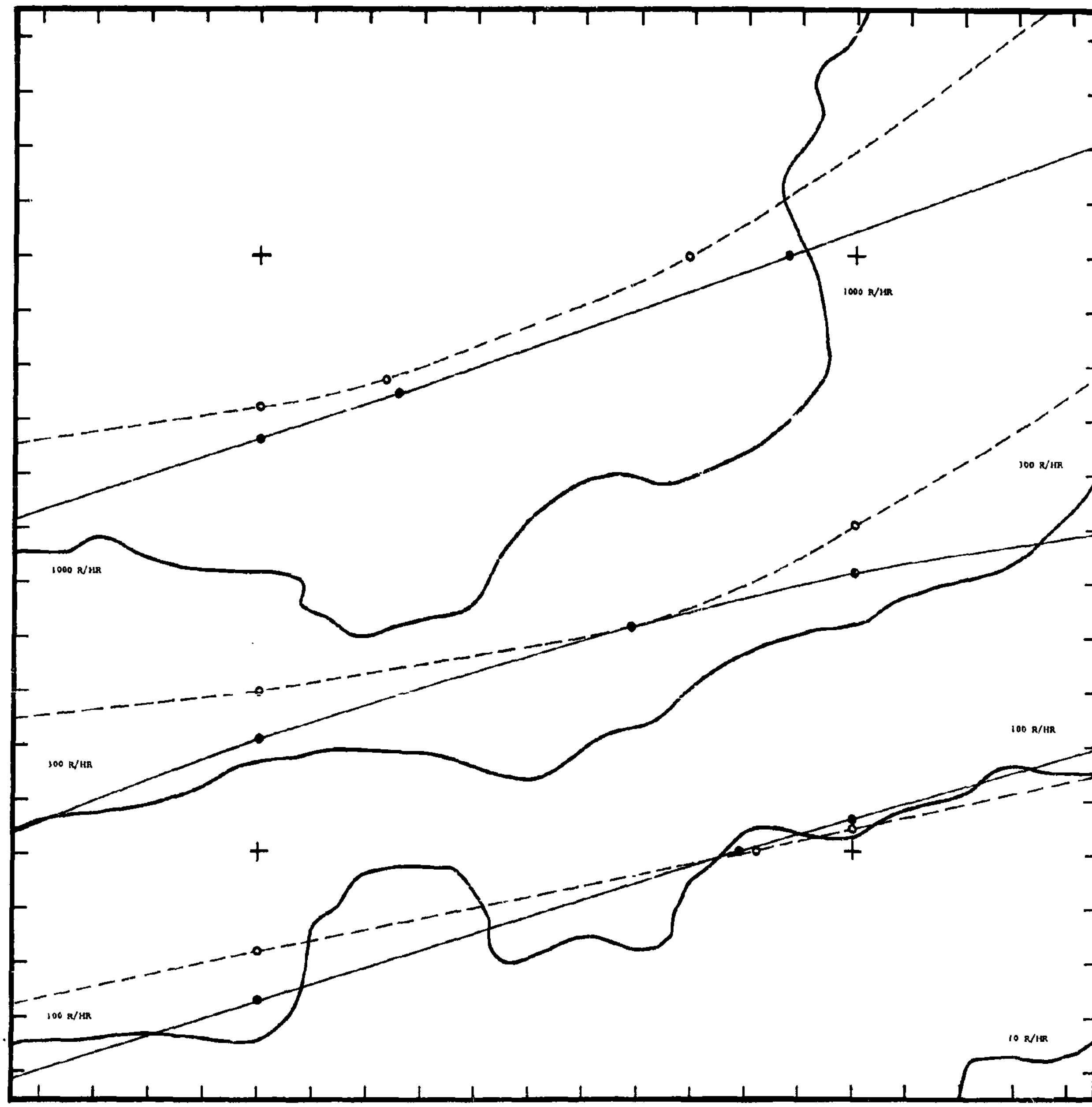
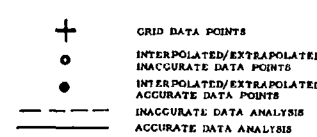


Figure 9. Comparison of Original Fallout Contours with Analyses Based on Accurate and Inaccurate Data from 4 Grid Points



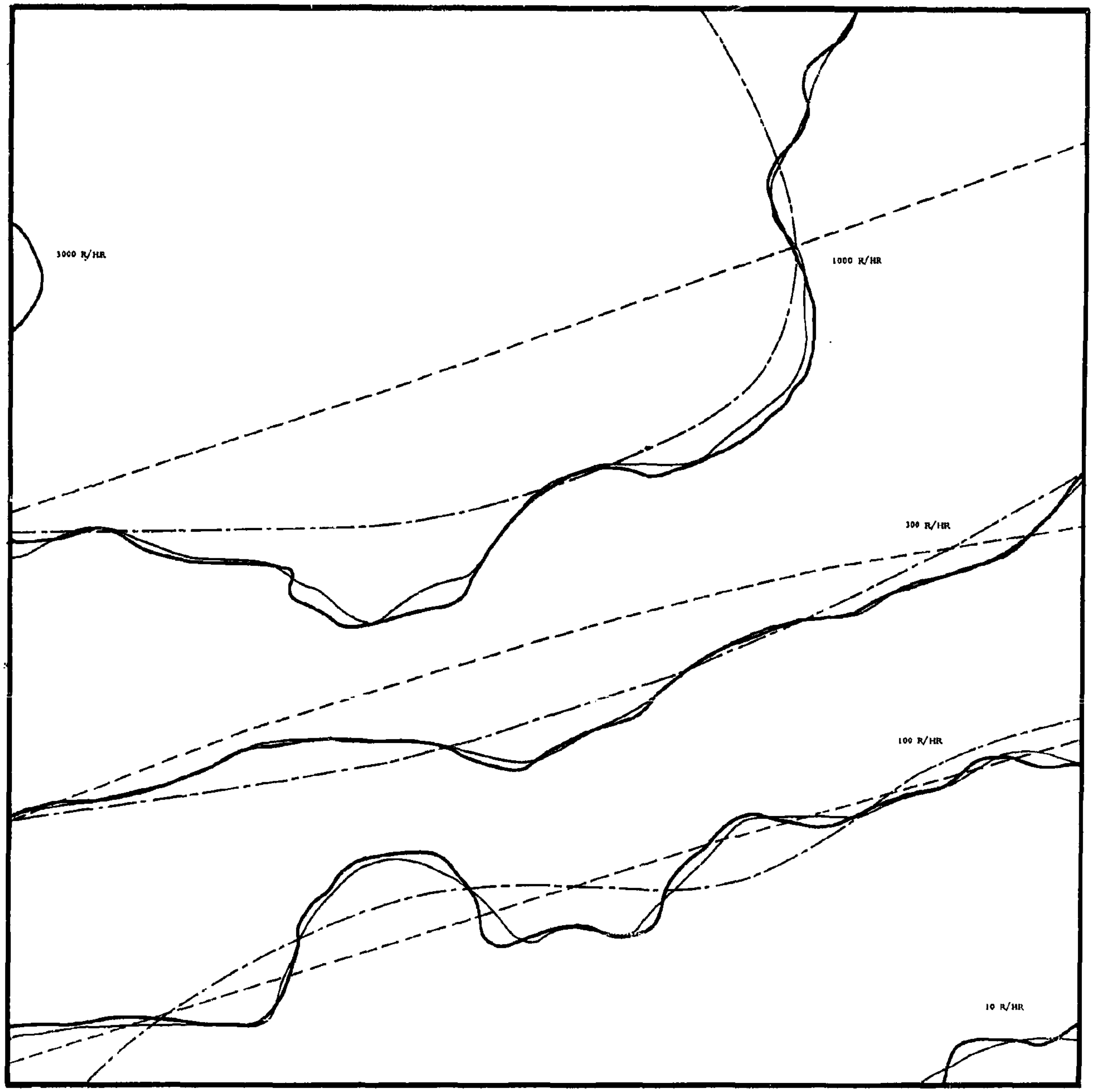


Figure 10. Comparison of Original Fallout Contours with Analyses Based on Accurate Data from 400, 16 and 4 Grid Points

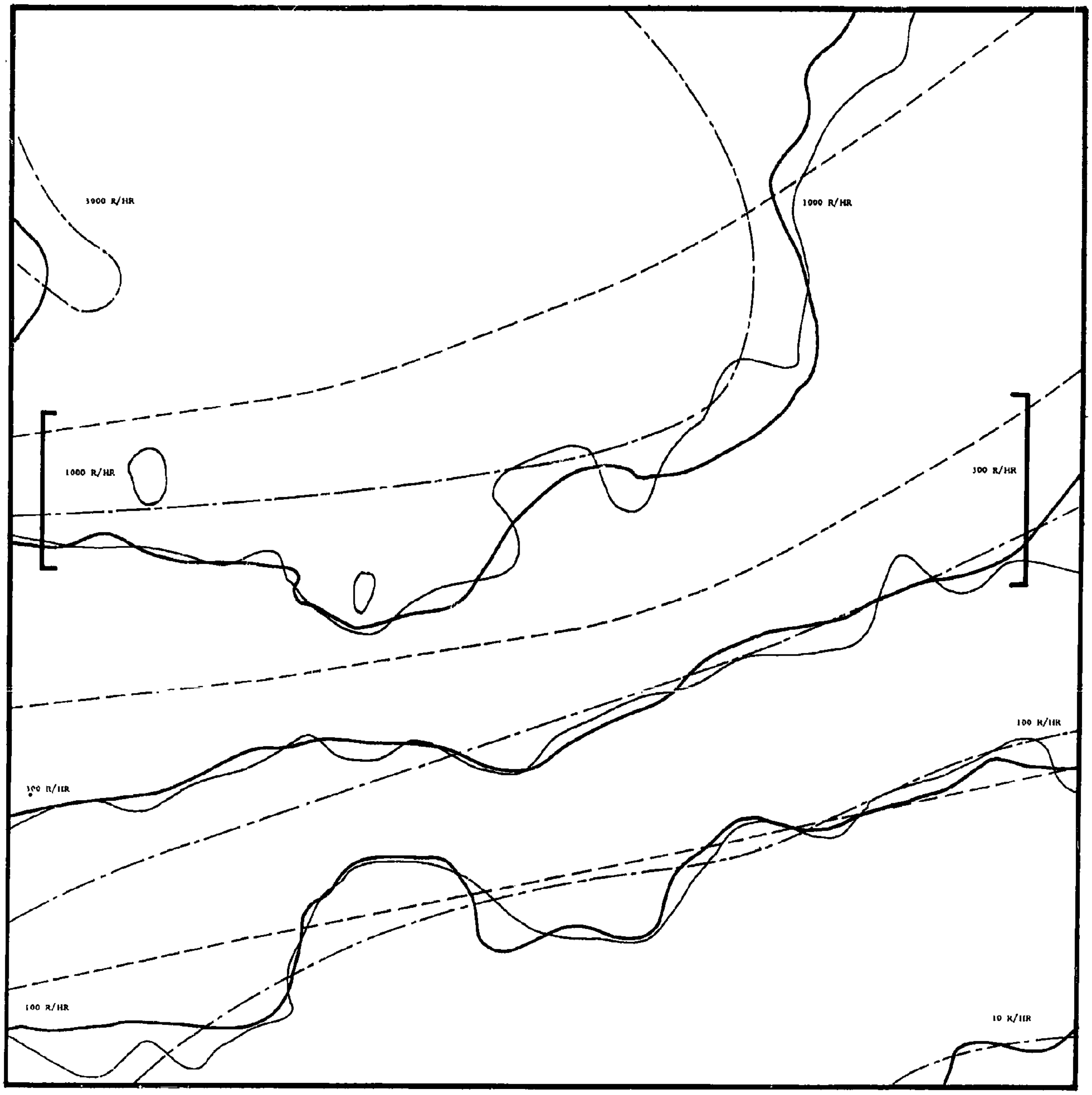


Figure 11. Comparison of Original Fallout Contours with Analyses Based on Inaccurate Data from 400, 16 and 4 Grid Points

4 POINT ANALYSIS
16 POINT ANALYSIS
400 POINT ANALYSIS
ORIGINAL CONTOURS

TABLE 1

CALCULATED MEASURES OF ERROR IN SAMPLE ANALYSIS

	AVERAGE ERROR						MEAN DEVIATION					
Analysis	10	100	300	1000	3000	All	10	100	300	1000	3000	All
400A	+2.1	-0.7	-1.8	-1.4		-1.1	0	2.75	1.5	1.0		1.8
400I	-2.5	+1.9	+ .2	-3.6	+10.5	- .2	5.6	8.6	7.9	7.0	2.1	8.0
16A		-1.5	+8.4	-6.9		0		18.3	14.3	5.7		13.8
16I		-0.4	+22.7	-13.3		+3.1		15.0	19.1	6.8		18.3
4A		-0.6	-26.0	- 5.2		-10.5		10.8	11.7	28.0		19.1
4I		-10.9	-39.3	-15.5		-22.4		14.6	5.7	19.4		17.3

be placed in the 0.9 difference between them because the measures of precision, 1.8 and 8.0 respectively, are large relative to that difference. On the other hand, it is reasonable to believe that there is a real difference in the precision of the two analyses because of the relative magnitude of the two measures of precision (1.8, 8.0), and the difference between them (6.2).

Figures 7 through 11 compare various analyses with each other and with the original contour analysis from which all of the test data in this package were derived. Table 26 contains measures of accuracy and precision for each line of each analysis, and for each analysis as a whole. Study and compare these analyses and their associated measures carefully so that various values of these measures will have meaning for you in terms of displacement and similarity of contour. You will then be able to evaluate test results by comparison with the values that you select as being representative of a quality of analysis that you feel is proper.[1]

Figure 7 compares the original contours with analyses of accurate and inaccurate unit time reference dose rate data from the entire grid of 400 points. The analysis based on the accurate data is represented by a thin solid line; that based on inaccurate data by a thin dashed line. Both analyses were very carefully conducted under ideal working conditions, as were all of the analyses illustrated in these figures. Calculating aids and variable scales for logarithmic interpolation of the data were used. They may therefore be thought of as the best performance which could be expected of an analyst, given the quality and quantity of the data.[2]

The contour lines of both analyses in Figure 7 are very uniformly superimposed upon the true contours; but the inaccurate data analysis is much more irregular and variable than the accurate data analysis. These observations

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[1] You may wonder why, if this is to be the means of evaluation, the comparison is not made directly between the test analysis and the reference analysis. It is because calculated measures permit a more objective comparison of one analyst, or system, with another, and with the same analyst or system at a later date; and because they are easier to store, reproduce and transmit to other interested persons.

[2] For nearly all of the contour lines, the measures are based on a sample of about 15 test points, so the confidence which can be placed in them is the same as that which can be placed in measures generated using this test package.

agree with the measures of accuracy (-1.1 and -0.2 respectively) and of precision (1.8 and 8.0 respectively) for the complete analyses.[1]

As a rule, the lack of precision in an analysis will be evident in the smoother contours of the analysis as compared with the original. This is true here in the accurate data analysis. In the inaccurate data analysis, however, the lack of precision is evident in the more irregular contours of the analysis as compared with the original. This indicates that the grid spacing is so fine that it is the errors in the data themselves which are being analyzed, and that for data of this quality a limit in precision has been reached. This is one very important reason for measuring system performance.

Figure 8 compares analyses based on accurate and inaccurate data from 16 points with each other and with the original contours. Note that the over-all measures of accuracy for these two analyses are not significantly different from those for the analyses based on 400 points, but that the measures of precision have increased to 13.8 and 18.3 respectively. Note also that the inaccurate data analysis is smoother than the original. This indicates that greater precision could be obtained with more data. This, and the results of the 400-point analysis indicate that the optimum number of data points, for this quality of data, lies somewhere between 16 and 400 points: the exact number could be determined by repeated trials (simulation) with different numbers of data points.

Figure 9 compares analyses based on accurate and inaccurate data from 4 points with each other and with the original contours. Note that the accuracy of these analyses is much poorer than the accuracy of those in Figures 7 and 8, but that the precision is not very different from that of Figure 8. In this case, most of the imprecision is due to the failure of the analysis to discriminate the curvature in the 1000 R/HR contour. In a different situation--one where the curvature of all contours was similar to that of the 100 and 300 R/HR contours--the precision would be of the same order as that of Figure 7. This illustrates the point that the required degree of precision is related to the degree of curvature which it is desired to discriminate.

Figure 10 compares accurate data analyses based on data from 400, 16 and 4 points with each other and with the original contours. Figure 11 does the same for inaccurate data analyses. These figures show clearly the pattern of degradation in accuracy and precision which results as the number of data points is reduced.

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[1] Generally speaking, an analysis based on inaccurate data will be less precise but not necessarily less accurate than an analysis based on accurate data. This is because the inaccuracies have a chance to cancel each other out if their average is zero

FIGURE 12

RADEF SYSTEM EVALUATION SCORING SHEET[1]

Fallout Arrival Prediction

0930______ 1000______ 1030______ 1100______ 1130______

0945______ 1015______ 1045______ 1115______ 1145______

Fallout Completion Prediction

0930______ 1000______ 1030______ 1100______ 1130______ 1200______ 1400______

0945______ 1015______ 1045______ 1115______ 1145______ 1300______

Maximum Dose Rate Prediction

1000______

1100______

Decay Rate Estimation

1200______ 1300______ 1400______ 1500______ 1600______

Future Dose Rate Prediction

1, 19______ 19, 1______

Contour Analysis

1-1/2, 1-1/2____ 1-1/2, 13-1/2____ 7-1/2, 1-1/2____ 7-1/2, 13-1/2____
13-1/2, 1-1/2____ 13-1/2, 13-1/2____ 19-1/2, 1-1/2____ 19-1/2, 13-1/2____

1-1/2, 7-1/2____ 1-1/2, 19-1/2____ 7-1/2, 7-1/2____ 7-1/2, 19-1/2____
13-1/2, 7-1/2____ 13-1/2, 19-1/2____ 19-1/2, 7-1/2____ 19-1/2, 19-1/2____

Accuracy______
Precision______
Legibility______

Decay Rate Used______

Over-all Evaluation of Contour Analysis

Excellent______
Good______
Acceptable______
Poor______
Unacceptable______

[1] Enter calculated percent error in all numbered spaces, calculated measures of accuracy and precision in the space provided for them, and subjective rating of Very Clear, Clear, Unclear, or Illegible in the space for legibility.

C. DETAILED DESCRIPTION OF A TEST FOR MEASURING THE MUSTERING CAPABILITY OF LOCAL AND STATE CIVIL DEFENSE CENTERS

1. Introduction

A large number of civil defense activities depend upon paid or volunteer civil defense personnel manning preassigned positions in the event of a nuclear attack. At any given point in time it is to be expected that a certain number of the assigned personnel will not be available to man their positions. Some may be on business trips, others on vacation, some sick, while others are simply unavailable for one reason or another. Thus, it is of some importance to a civil defense organization to have a measure of the number of assigned personnel who will actually be available for duty if the need arises. The purpose of the mustering plan test is to provide such an estimate. A test has been developed which will provide reliable estimates of personnal availability requiring a minimum expenditure of effort on the part of the civil defense organization.

The mustering plan test does not attempt to measure the motivation of a civil defense worker to man his assigned post. It is possible that an individual will be "available" in the sense that he is near enough to his post of duty to get there before the arrival of fallout, but in the event of an attack he may well seek personal safety or the safety of his family rather than fulfill his obligations to civil defense. Thus, the estimates of personnel availability made by the mustering plan test must be construed as the maximum number and kind of personnel that the civil defense organization can expect to report for duty in the event of an emergency.

The test presented in this section is applicable to the local, county, state, region, and federal level of civil defense command. Because of the nature of the test, however, it will be most useful in its complete form for those civil defense activities that include a large number of people.

The technique selected to measure personnel availability is basically a sampling procedure. It requires that the availability of a sample of individuals expected to participate in a specific civil defense activity be determined at various points in time. From this sample the expected number of personnel available for the activity at any given time can be estimated. Two sampling plans are provided as part of this test. The first plan requires a fairly large sample and is used to estimate the number of civil defense personnel that can be expected to muster. The second plan requires a somewhat smaller sample and is used to determine the validity of the first estimate over time.

This section is divided into three parts. Following this introduction, the fundamentals of the mustering plan test are discussed. The discussion is intended to provide the test administrator with a non-technical description of the "how" and "why" of the test. The third part of this section contains a detailed description of the procedure to be used in administering the test.

2. Fundamentals of the Mustering Plan Test

This portion of the discussion contains a general outline of certain important points of the mustering plan test. The first topic that will be considered is the division or stratification of the civil defense organization into separate and identifiable activities.

An activity is defined as a group of individuals with the necessary equipments, skills, and knowledge, working together to perform a specified function. The individuals may be working in close proximity to each other as, for example, a damage assessment team in a state control center. Or, on the other hand, the individuals may be geographically dispersed as in the case of a radiation monitoring net. Each such group constitutes an entity with an assigned function to perform. The degree to which the entity is capable of performing its function is determined, among other factors, by the number of individuals available to the group when needed.

It should be pointed out that the mustering plan test is not designed to show how many individuals must be available to a group to enable it to adequately perform its function. This is a matter for local decision. Once this decision has been made, however, the results of the test will provide an indication of how many of the total group assigned will be available for the activity in question at any given time. Thus, the test might be of some value in determining how many civil defense workers should be assigned to a group to insure that the minimum number critical to the adequate functioning of the group will show up in the case of an emergency.

A civil defense organization is then composed of a number of related entities, each assigned a particular function, and the success or failure of the organization depends upon the effectiveness of its component groups. The first step in considering the muster of personnel is to divide the civil defense organization into its operating entities so that personnel muster can be considered for each such entity. The names of operating groups may vary among civil defense organizations, particularly at the local community level; therefore, no attempt will be made here to identify such groups. It is believed the civil defense director or the administrator of tests for the organization will have little trouble

dividing the organization into operating groups. This division has probably already been made on the organization chart for the community civil defense organization. Some examples of civil defense functions that require specific groups or teams of individuals are listed as follows:

- Radiation monitoring
- Analysis of radiation data received from the monitoring net
- Shelter management
- Control center communications
- Shelter communications
- Damage assessment
- Traffic control.

There are certain individuals or small groups where a sampling of their availability is not necessary and, hence, they are not to be included in the mustering plan test. The availability of each of these individuals is always known to the civil defense organization or to the individual's deputy, who is always informed as to when he (the deputy) has the assigned responsibility. For example, the local civil defense director can be expected to keep the organization and his deputy informed of his availability. Similarly, for the operations officer and other key individuals within the organizations. There are certain personnel who hold responsible positions in the local government and who double as civil defense workers, essentially in the same position. The regular job of these persons requires them to keep the local government informed of their availability or to be certain that a responsible deputy has fulfilled the position in their absence. Examples are: the police chief, fire chief, supervisor of public works, etc. Each of these jobs has an important civil defense function, but in the absence of the chief a deputy is always available to both the local government and civil defense.

What has been said so far in this portion of the report can be briefly summarized in the following few words: The availability of CD personnel must be considered in terms of the operating groups that make up the total civil defense organization. Also, the test administrator must identify the operating groups and test the muster capability of each group separately. The availability of an operating group, in order to have meaning, must be related to time. Time of availability is the next topic to be discussed.

It is well known to those experienced in public opinion sampling that human behavior patterns are generally pretty much the same during the working hours of a day. Also, behavior patterns are quite similar for an individual during the evening and night hours of a working day, but of course markedly different from that of the daytime pattern, especially in the case of a commuting population. Weekends and holidays also usually present a pattern peculiar to themselves. Because these behavior patterns vary for different time periods, it is to be expected that the availability of personnel for civil defense activities will vary also. The particular point in time that a nuclear attack might occur cannot be predicted. Therefore, since the time of need for civil defense cannot be predicted, the availability of personnel must be estimated for any point in time. This is accomplished, as a practical matter, for this test technique by dividing time into three categories, as follows:

- Weekdays - between 0800 and 1700 (i. e., the normal working hours)
- Weekdays - between 1700 and 0800 for Monday to Thursday, inclusive
- Weekends and holidays - between 1700 of the preceding day to 0800 of the next working day.

Dividing the time into the above three categories assumes that the availability of civil defense personnel is essentially the same within each category but may differ significantly between categories. For example, it might be found that 98 per cent of the civil defense personnel assigned to a particular activity are in the vicinity of their assigned post during the working hours but only an estimated 60 per cent are available during weekends and holidays. Similarly a different percentage might be estimated for the evening - night hours. Because this difference can exist (and probably will) the availability of each operating entity must be measured during each time period.

It was mentioned in the introductory section that the mustering plan test consisted of sampling the individuals within the group being tested. It was also pointed out that two sampling plans constituted the test--one plan to estimate the availability of personnel as a function of time period, and the second plan to check the validity of the original estimate periodically. The next topic of discussion is the description of the two sampling plans.

a. <u>The Initial Sample</u>

The purpose of the initial sample is to estimate personnel availability for a particular civil defense operational group. The purpose of the sequential sampling plan (to be discussed later) is to estimate whether or not the estimate

made from the initial sample remains valid as time passes. The sample taken with the sequential sampling plan will be smaller than that required by the initial sample.

The civil defense test administrator charged with using a sampling plan must know the answer to three questions. These questions are: 1) How will the sample be taken? 2) How large should the sample be? and 3) How often should a sample be taken? These questions are discussed in the following paragraphs.

1) How will the sample be selected? The most critical consideration initially is the basis for selecting the sample. It can be assumed that any community, or CD activity group, is similarly affected by those factors which determine an individual's availability to perform his civil defense duties, e.g., hours at home versus hours at work, weekend or holiday activities, etc. If this is the case, there is little reason to stratify or divide the groups to be sampled into specific categories in order to assure true representativeness of the sample taken. Therefore, a random sampling technique is preferred to other possible methods of obtaining a representative measure of personnel availability for civil defense duties.

The importance of true randomness in such sampling cannot be over-emphasized. It is so important that most of the "cockeyed" results that come from sampling studies can be traced to the lack of randomness in selecting the sample. The mechanics of selecting a random sample are discussed on Pages 73 and 74; however, many of the ideas presented there are repeated here.

A random sample merely means that each individual in the operational group being sampled has an equal chance of being included in the sample. In other words, the selection process does not discriminate in favor of or against any one or group of individuals. It sounds easy to select a sample at random, but this is deceptive. It is claimed, for example, that without some mechanical aid or procedure it is impossible for an individual to select a random sample of books from his own bookcase.

The civil defense test administrator is not only interested in the availability of individuals composing an operating group, but must also be interested in their availability within the divisions of time noted earlier in this section. Thus, the selection of a random sample is somewhat complicated. First, random points in time must be selected within each time division and then the sample of individuals to be associated with the time points must be randomly selected from all personnel within the operational group.

The random points in time are selected by firist dividing the time division into fifteen minute intervals. Thus, for the time division of the five weekdays from 0800 to 1700 (i. e., 8:00 a. m. to 5:00 p. m.) there are 180 such time intervals. The problem now is to select randomly the number of time intervals from this population of 180 required by the sample. One way of making this selection is to write each time interval on a small card and put each card into a container. Next the cards must be mixed very well--it is the mixing which introduces the randomness. The final step is to then draw the required number of cards from the container; however, each card must be put back into the container after the time interval it represents has been recorded. If the cards are not replaced, then the sample is no longer "honest" (i. e., random) because the chance of any given card being selected changes as the number of cards in the container decreases. Replacing the card also permits any time interval to be drawn at random more than once, which would be necessary if the total sample were greater than the number of time intervals used. A second method of selecting a random sample is by using random numbers. This method is preferable to pulling cards from a container but requires a table of random numbers. A table of random numbers can be procured through the Office of Civil Defense, or from most standard texts on statistics. The random number method of selecting a random sample is discussed on Pages 73 and 74.

At this point a list of time intervals corresponding to the established sample size has been randomly selected. The problem now is to randomly select the sample of individuals from the operating group to associate with the time intervals. This can be done by again writing the names of the individuals on small cards, mixing the cards in a suitable container and selecting the names one by one, replacing each name after it has been associated with a time interval. Random numbers can also be used to select the sample of individuals and the method for doing this is also discussed on Pages 73 and 74.

The time period chosen for the preceding discussion was for the hours of 0800 to 1700 of weekdays. However, it should be remembered that a sample must also be selected for the other two time periods. Furthermore, the procedure must be repeated for each operational group within the civil defense organization.

The sample of individuals and time intervals having been selected, it remains to contact each individual and determine if he is available for duty during the time interval associated with his name. The term available is used here as it is used throughout this section to mean that the individual can get to his assigned duty post. In effect, this means that he can get to his duty post between the time he receives a warning and the time of fallout arrival or

any other event that might prevent him from mustering for duty. How much time an individual can count on will vary from locality to locality and, therefore, to some extent is a figure that must be selected locally. However, it is believed unwise to assume for test purposes that more than 45 minutes will elapse before the arrival of fallout.

An individual can be contacted, of course, by a telephone call and it can be determined if he were near enough to his duty post to reach it with appropriate equipment within 45 minutes on the day in question and during the time interval of interest. The individuals should be contacted at the precise time interval specified for in the sample; however, it is doubtful if a civil defense worker (especially volunteers) would look kindly on being roused out of bed at 2:00 a.m. to determine if he could go to his prescribed post. Therefore, it is suggested that such a procedure not be adopted. Instead, it is acceptable from the sampling point of view to call an individual at a reasonable hour as soon as possible after the designated time and ask him to recall his activities and hence his availability at the appropriate time and day. Public opinion samplers have found that the hours between 6:00 p.m. and 8:00 p.m. are an excellent time to call because most people are at home during this period.

There will be some civil defense activities where the individuals included in the activity are sufficiently separated geographically so that telephone contact is costly. If such expenses cannot be tolerated, contact can be made by mail. Mail is much less desirable than direct voice contact, but it is better than no contact at all. The problem of defining the content and format of the questions to be asked of the sampled individuals will be discussed on Page 54.

2) The second of the three questions that were posed earlier in this section was how big a sample should be taken. The size of the sample depends largely upon two factors which will now be discussed.

It must be realized that estimating the availability of all the individuals in an operating group from a sample of these individuals is a process containing inherent errors. For example, if 90 per cent of the individuals sampled are available, it does not mean that 90 per cent of all individuals constituting the operating group are available. The true availability might be 95 per cent, 85 per cent, 76 per cent, etc. However, the error between true availability of the entire group and the availability estimated from the sample can be reduced by increasing the sample size. Thus, one factor determining the size of the sample is how small an error is desired

between estimated availability and true availability. The accuracy required of the estimate derived from the sample will be influenced by many things, among which is the state of the international situation. Thus, this section deals with two measures of accuracy and with their two corresponding sample sizes. The idea here is that during periods when the need for civil defense becomes very apparent a larger sample with greater accuracy would be desirable, but when interest in civil defense is "normal" the accuracy of availability estimates need not be so great; hence, a smaller sample can be taken.

The first measure of sampling accuracy is that of ± .075. This means that the true availability of the operating group will be within a range of ± .075 of that estimated from the sample for most of the samples taken. For example, if it is found that .80 of the individuals sampled are available, then the true availability of the operating group lies between .725 and .875. The second accuracy interval is ± .05 and has the same relative meaning (i.e., for .80 available the range is .75 to .85).

The phrase "...... for most of the samples taken" has been used twice in the preceding paragraphs and represents an admission that regardless of what accuracy interval is selected for the sample there is a chance that the true availability will not be within this interval. This is the second factor that influences the size of the sample. The chances that the true availability falls within the accuracy interval are increased as the sample size is increased. Thus, increasing the sample size provides a certain confidence in estimating how close the true availability is to that found in the sample. In the illustration of the preceding paragraph one can say that the true availability lies between 72.5 per cent and 87.5 per cent, but how confident is this statement? It turns out that it can be a very confident statement. One could take a large enough sample to state flatly that for 999 out of 1000 samples that are taken the true availability will lie between 72.5 per cent and 87.5 per cent. To make this kind of a statement would require a very large sample indeed. On the other hand, the sample size could be small enough so that one would have to admit that the true availability will actually be within this accuracy interval for only, say, 60 out of every 100 samples taken. This would require a relatively small sample.

There are two sets of sample sizes provided as part of this test, one for an accuracy interval of ± .075 and the second for an accuracy interval of ± .05. The confidence associated with the first of these sample sizes is .90 and with the second is .95. This means that the estimate of true availability as made from the sample lies within the accuracy interval in about 90 out of every 100 samples taken, but for 10 out of 100 samples the availability estimate lies outside of the accuracy interval. Similarly for the case of a confidence of .95.

The sample sizes are presented in Tables 2 and 3. Table 2 contains sample sizes required to insure an accuracy interval of $\pm .075$ with a confidence of .90. Table 3 contains sample sizes for an accuracy interval of $\pm .05$ with a confidence of .95. It can be seen that the sample sizes in Table 3 are significantly larger than those shown in Table 2.

The first column in each of the tables is labeled "p" and it can be seen that the sample size also varies with "p." These different sample sizes are introduced to assist the test administrator to utilize any information about the availability of an operating group that he might have. The term "p" is the estimate of availability made by the test administrator. If the availability is totally unknown, then let "p" be equal to .5, because this requires the largest sample. However, if from a small sample or a large sample taken previously the test administrator knows that the availability is "about .8" or about some other value, then the size of the sample can be reduced substantially. It is believed that this will be particularly helpful when using the sample sizes of Table 3 where presumably the previous history of "p's" from the smaller samples of Table 2 can be used as an approximation.

3) The last of the three questions posed earlier is how often to sample test. The answer to this is simply that the civil defense activity must be resampled whenever the results of using the sequential sampling plan indicate that the availability of the activity has changed. One may, however, ask how often then should the sequential sampling test be applied to an operating group? It is intended to discuss the sequential sampling plan in the next part of this section, but it is believed to be in order to perhaps jump the gun a bit and consider here the time between sequential samplings.

At the beginning of this section three divisions of time were defined. It is assumed that the availability of any operating group remains essentially the same during each of these time divisions. Thus, once the availability has been sampled there is little reason to remeasure it unless the sample results are determined to be untrue. (Remember, 10 out of 100 can be expected to fall outside the accuracy interval.) If the sample is obviously not true it can be discarded and a new sample taken. However, once a valid estimate has been made, why repeat the measurement? The answer to this is simply don't repeat the measurement unless there is reason to believe that something has happened to invalidate the results. Thus, the sequential sampling plan should be used whenever it appears that the availability might have changed. There are a number of reasons why availability might change. For example, the interest in civil defense waxes and wanes as emergencies or near emergencies occur. It is to be expected that personnel availability will change with the seasons. More people will be

Table 2

Initial Sample Size for
Accuracy = $\pm$ .075 and
Confidence = .90

p	sample
.1	44
.2	77
.3	102
.4	116
.5	121
.6	116
.7	102
.8	77
.9	44

Table 3

Initial Sample Size for
Accuracy = $\pm$ .05 and
Confidence = .95

p	sample
.1	138
.2	246
.3	323
.4	369
.5	384
.6	369
.7	323
.8	246
.9	138

out of town on vacation in the summer, for example. The availability of volunteer workers will be especially unstable. Therefore, how the sequential sampling plan is used is, to a large extent, a matter of local decision. The availability should certainly be checked at least once within each season (i.e., fall, winter, summer and spring), and checked whenever local conditions are such as to suggest that the availability might have changed.

One final point should be made in regard to using the sequential sampling plan to check availability. As was mentioned earlier, the sequential plan should require a smaller sample than the initial sampling plan. If sequential sampling suggests that the availability of a given group has changed significantly, then the initial (or total) sampling must be repeated to re-estimate the availability. The data collected for the sequential plan, however, need not be discarded but can become part of the data needed for the total sample. In other words, the sequential sample will be enlarged to conform to the sample size shown in Table 2 or 3, using the prescribed procedures for randomization.

b. Sequential Sampling

The purpose of the sequential sampling plan, as pointed out in the preceding paragraphs, is to check the results of the initial sample. For example, suppose it is found that 90 per cent of the shelter managers in the city are available for duty during the working hours of the month of January. There may be some doubt that the same percentage would hold for the month of March. The validity of the 90 per cent estimate can be checked with the sequential sampling plan. There is no reason, of course, why the initial sampling plan could not be used again in March, but the sequential sampling plan should require a smaller sample and hence should reduce the testing workload imposed upon the civil defense organizations.

The discussion of the sequential sampling plan will center around the chart shown as Figure 13. A chart similar to this one is required for each estimate of "p" (i.e., the availability). Part 3 of this section contains the procedure for administering the test and includes nine such charts. (For p = .1, .2, .3, .4, .5, .6, .7, .8, .9.) The chart of Figure 13 is presented for illustrative purposes and was not calculated for any real value of "p".

It can be seen from Figure 13 that the chart is divided into three regions labeled reject, accept, and continue sampling. It can also be seen that a minimum number of individuals must be sampled before any decision

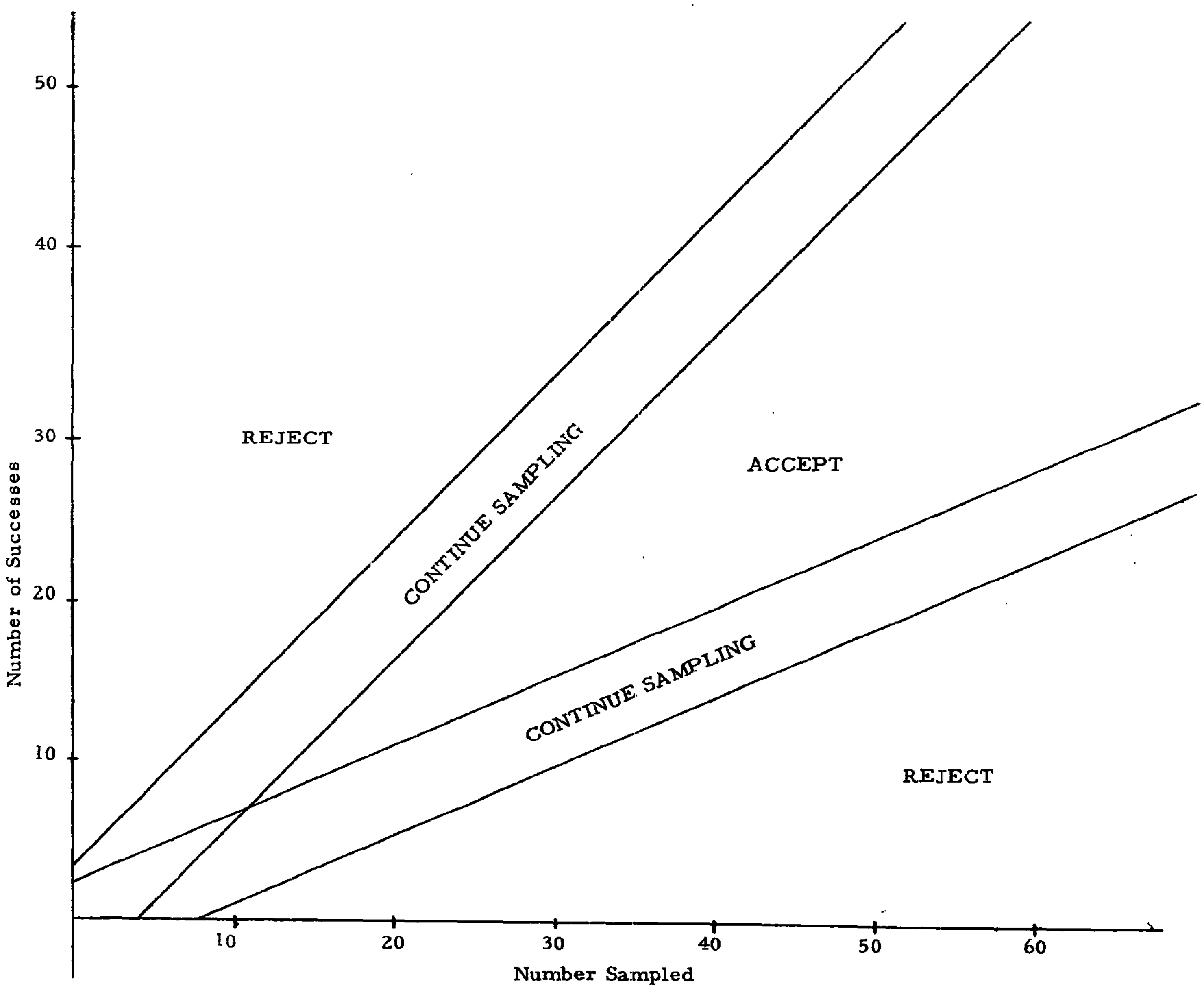


Figure 13. Illustration of Sequential Sampling Plan

to accept or reject the estimate can be made. For the chart shown in Figure 13, this minimum number is nine. This presumes that the first nine individuals sampled were unavailable. When the tenth individual is queried the number available (shown as "successes" on Figure 13) is totaled. If all ten in the sample are not available, then the estimate of availability can be discarded. However, suppose as a result of the first ten queries it is found that six people are available. Referring to Figure 13, it can be seen that with six successes in a total sample of ten, the sampling process must be continued or, in other words, it cannot be concluded that the availability has or has not changed. The next step then is to query another individual in the operating group and determine if he is available. This process is continued until the number of successes in the sample shows that the estimated availability can be accepted or rejected. It is only necessary to have one point in the accept or reject region to cease sampling with this plan.

The selection of individuals must be random for the sequential plan. Either the method for selecting a random sample discussed previously for the initial sample can be used or the method using random numbers presented in Part 4 of this section.

If the number of successes are greater than expected and the estimate of availability is rejected because points begin to fall in the upper reject region of Figure 13, then it can be concluded that the availability has increased. Similarly, if the estimate of availability is rejected because points begin to fall in the lower reject region, then it may be concluded that the availability has decreased. This information may be of value in selecting the sample size from Tables 2 and 3 when the availability is re-estimated with a larger sample.

There is one other point that will be discussed with regard to the sequential sampling plan. It is possible that, as the sampling progresses, all points fall in one or the other of the continue sampling bands. This is both monotonous and irritating. It will occur when a small change has occurred in the availability estimate. If this happens, the sampling should stop when the sample size is big enough to be considered as an initial sample as shown in Tables 2 and 3. When the sample size reaches this point, merely use it to recompute an estimate of availability.

The technical development of the sequential sampling plan is complex and is, therefore, deferred to Part 5 of this section.

c. Content and Format of the Test

Previous portions of this section have concentrated primarily on the techniques for selecting and contacting a representative sample of a specified civil defense group, in order to provide a test of CD mustering plans. However, if we are to have a valid test, we must be sure that we obtain the correct information from the respondents sampled. The determination of an individual's availability, once contacted by phone or mail, might at first appear ridiculously simple. And, indeed it is if we are uncritical in our definition of "available." As was suggested earlier, we can only be confident that an individual will be available to perform his defense activities, since we have no way of knowing what he will ultimately do in the event of a nuclear attack. Personal or family needs, fear, confusion, or injury could render him ineffectual for civil defense work in the event of an actual crisis. By the same token, an individual's personal motives may influence his responses to a test of the mustering plan, whether consciously or not. Besides errors in memory which might result if an individual were asked about his availability to undertake his civil defense duties at some time in the past, there is the possibility of erroneous interpretation of the situation in question. For this reason it would be better to get answers of a factual nature as well as the individual's opinion concerning his availability. In other words, where he was, for what purpose, under what conditions and with what kind of transportation, would be critical in the interpretation of a respondent's statement of availability.

The content and a suggested format for the inquiry to be used for both telephone and mail samplings are illustrated on pages 83 and 84. Answers to all of the questions should be obtained as a standard procedure. These data will help a CD director or test administrator to determine why changes in availability occur (e.g., vacations, etc.) and thus predict more accurately what future availability of his civil defense workers will be as a function of season, weather conditions and other variables not measured directly in the test sampling.

3. Test Administration

The following paragraphs contain a discussion of the administration of the mustering plan test. The discussion is centered around an illustrative application of the test to a specific civil defense activity. It is believed that the illustration is presented in sufficient detail to guide the test officer in applying the test to his own operating groups.

The operating group chosen for this illustration is a group of shelter managers. The time period of interest is the weekday hours between 0800-1700. It will be supposed that from previous sampling it can be estimated

that shelter manager availability is about 90 per cent (i.e., "p" of .9). Thus, the required sample size is found from Table 2 to be 44. If availability is not approximately known then the largest sample of Table 2 should be taken. That would be 121 corresponding to a "p" of .5. Each of the steps in applying the test will now be discussed.

a. Random Sample of Time Intervals

There are 45 hours or 180 fifteen-minute intervals in the time period of interest. First, form a table as shown in Figure 14. This table is nothing more than a listing of each time interval and its associated day. Each time interval is then numbered in order with a three-digit number. If there were 100 time intervals or less, then a two-digit number (00 to 99) would be sufficient. Similarly, if there were more than 1000 time intervals then a four-digit number would be required for each interval. It should be noted that once the table of 180 time intervals has been formed it can be used over and over for all tests in this 45-hour time period.

It is from Table 4 that the sample of 44 time intervals is randomly selected. In the case of this illustration the selection was done with the aid of random numbers. Random number tables are usually prepared in the form of columns of five-digit numbers. The first three digits of these five-digit numbers were used to select the sample. The sample selection is simple and merely consists of running down the column of random numbers until one is found between 001 and 180. The first random number happened to be 073 which corresponds to Tuesday at 0800-0815. This time interval and day then forms the first entry of a table as shown in Table 5. Next continue down the column of random numbers until another number lying between 001 and 180 is found. For these illustrations the next number was 137 which corresponds to Thursday at 1500-1515. This becomes the second entry in Table 5. This procedure is repeated until there are 44 entries (i.e., the sample size) in the table.

b. Random Sample of Shelter Managers

The second step in the application of the mustering plan test is to select randomly names of shelter managers to associate with each of the time intervals of Table 5. The roster of shelter managers might appear as shown in Figure 14. It can be seen from Figure 14 that in this illustration there are 17 shelter managers and that a two-digit number has been assigned to each name. Because there are less than 100 names on the list of shelter managers it is necessary to use only two-digit numbers from the table of random numbers.

Monday		Tuesday		Wednesday	
001	0800-0815	037	0800-0815	073	0800-0815
002	0815-0830	038	0815-0830	074	0815-0830
003	0830-0845	039	0830-0845	075	0830-0845
004	0845-0900	040	0845-0900	076	0845-0900
005	0900-0915	041	0900-0915	077	0900-0915
006	0915-0930	042	0915-0930	078	0915-0930
007	0930-0945	043	0930-0945	079	0930-0945
008	0945-1000	044	0945-1000	080	0945-1000
009	1000-1015	045	1000-1015	081	1000-1015
010	1015-1030	046	1015-1030	082	1015-1030
011	1030-1045	047	1030-1045	083	1030-1045
012	1045-1100	048	1045-1100	084	1045-1100
013	1100-1115	049	1100-1115	085	1100-1115
014	1115-1130	050	1115-1130	086	1115-1130
015	1130-1145	051	1130-1145	087	1130-1145
016	1145-1200	052	1145-1200	088	1145-1200
017	1200-1215	053	1200-1215	089	1200-1215
018	1215-1230	054	1215-1230	090	1215-1230
019	1230-1245	055	1230-1245	091	1230-1245
020	1245-1300	056	1245-1300	092	1245-1300
021	1300-1315	057	1300-1315	093	1300-1315
022	1315-1330	058	1315-1330	094	1315-1330
023	1330-1345	059	1330-1345	095	1330-1345
024	1345-1400	060	1345-1400	096	1345-1400
025	1400-1415	061	1400-1415	097	1400-1415
026	1415-1430	062	1415-1430	098	1415-1430
027	1430-1445	063	1430-1445	099	1430-1445
028	1445-1500	064	1445-1500	100	1445-1500
029	1500-1515	065	1500-1515	101	1500-1515
030	1515-1530	066	1515-1530	102	1515-1530
031	1530-1545	067	1530-1545	103	1530-1545
032	1545-1600	068	1545-1600	104	1545-1600
033	1600-1615	069	1600-1615	105	1600-1615
034	1615-1630	070	1615-1630	106	1615-1630
035	1630-1645	071	1630-1645	107	1630-1645
036	1645-1700	072	1645-1700	108	1645-1700

Table 4. Time Intervals for the Weekday Time Period From Which the Sample of Time Intervals is to be Drawn

Thursday		Friday	
109	0800-0815	145	0800-0815
110	0815-0830	146	0815-0830
111	0830-0845	147	0830-0845
112	0845-0900	148	0845-0900
113	0900-0915	149	0900-0915
114	0915-0930	150	1915-0930
115	0930-0945	151	0930-0945
116	0945-1000	152	0945-1000
117	1000-1015	153	1000-1015
118	1015-1030	154	1015-1030
119	1030-1045	155	1030-1045
120	1045-1100	156	1045-1100
121	1100-1115	157	1100-1115
122	1115-1130	158	1115-1130
123	1130-1145	159	1130-1145
124	1145-1200	160	1145-1200
125	1200-1215	161	1200-1215
126	1215-1230	162	1215-1230
127	1230-1245	163	1230-1245
128	1245-1300	164	1245-1300
129	1300-1315	165	1300-1315
130	1315-1330	166	1315-1330
131	1330-1345	167	1330-1345
132	1345-1400	168	1345-1400
133	1400-1415	169	1400-1415
134	1415-1430	170	1415-1430
135	1430-1445	171	1430-1445
136	1445-1500	172	1445-1500
137	1500-1515	173	1500-1515
138	1515-1530	174	1515-1530
139	1530-1545	175	1530-1545
140	1545-1600	176	1545-1600
141	1600-1615	177	1600-1615
142	1615-1630	178	1615-1630
143	1630-1645	179	1630-1645
144	1645-1700	180	1645-1700

Table 4 (Continued)

	Day	Time	Subject	Availability	
1	Wednesday	0800-0815	Turquoise	Yes	
2	Thursday	1500-1515	Black	Yes	
3	Wednesday	1530-1545	Brown	Yes	
4	Thursday	1145-1200	Yellow	Yes	
5	Thursday	0945-1000	Gray	Yes	
6	Monday	1315-1330	Ruby	Yes	
7	Thursday	1645-1700	Green	Yes	
8	Tuesday	1445-1500	Orange		No
9	Wednesday	1530-1545	Orange	Yes	
10	Friday	1045-1100	Blue	Yes	
11	Friday	1345-1400	Violet	Yes	
12	Wednesday	1000-1115	Rose	Yes	
13	Friday	1300-1315	Green	Yes	
14	Tuesday	0830-0845	Red	Yes	
15	Tuesday	0900-0915	Gray	Yes	
16	Monday	1300-1315	Gold	Yes	
17	Thursday	1630-1645	Pink	Yes	
18	Thursday	1415-1430	Turquoise	Yes	
19	Monday	0800-0815	Violet		No
20	Friday	0915-0930	Rose	Yes	
21	Monday	1515-1530	Blue	Yes	
22	Tuesday	1445-1500	Gray	Yes	
23	Monday	1030-1045	Orange	Yes	
24	Thursday	1515-1530	Blue	Yes	
25	Monday	0930-0945	Violet	Yes	
26	Tuesday	1330-1345	Hazel	Yes	
27	Wednesday	1530-1545	Violet	Yes	
28	Friday	1245-1300	Beige	Yes	
29	Wednesday	1645-1700	Yellow	Yes	
30	Monday	0800-0815	Ruby	Yes	
31	Friday	1415-1430	Violet	Yes	
32	Monday	0800-0815	Red	Yes	
33	Monday	1330-1345	Orange		No
34	Friday	1330-1345	Pink	Yes	
35	Tuesday	1200-1215	Rose	Yes	
36	Wednesday	1130-1145	Rose	Yes	
37	Monday	1200-1215	Red	Yes	
38	Friday	1600-1615	Ruby	Yes	
39	Monday	0915-0930	Hazel	Yes	
40	Tuesday	1245-1300	Rose	Yes	
41	Thursday	1145-1200	Hazel	Yes	
42	Wednesday	1100-1115	Turquoise	Yes	
43	Tuesday	1200-1215	Gray	Yes	
44	Thursday	1315-1330	Black	Yes	
				41	3
	Availability = $\frac{41}{44}$ = .93				

Table 5. Data Sheet for Shelter Manager Sample

Assigned Number	Alphabetical Listing
01	Mr. Beige
02	Mr. Black
03	Mr. Blue
04	Mr. Brown
05	Mr. Gold
06	Mr. Gray
07	Mr. Green
08	Mr. Hazel
09	Mr. Orange
10	Mr. Pink
11	Mr. Red
12	Mr. Rose
13	Mr. Ruby
14	Mr. Turquoise
15	Mr. Violet
16	Mr. White
17	Mr. Yellow

Figure 14. Roster of Shelter Managers

Returning now to the random number table the first number in the table between 01 and 17 was 14 corresponding to Mr. Turquoise. This name is now entered in the list of Table 5 opposite the time interval of Wednesday morning between 0800 and 0815. This means that the availability of Mr. Turquoise between 0800 and 0815 on Wednesday must be determined. The second number from the random number table was 02 which corresponds to Mr. Black. Thus Mr. Black becomes the second entry in the list of Table 5. This procedure is continued until 44 selections have been made from the list of 17 shelter managers shown in Figure 14. The sample has now been selected and the next step is to contact the individuals in the sample.

c. Determination of Shelter Manager Availability

The final step in the administration of the test is that of contacting the individuals included in the sample. The sample can be selected as far in advance of actual contact as desirable and it is recommended that the test officer select the sample. Contacting the individual in the sample, however, can be assigned to a clerk. The preferred way to contact the individuals is via telephone. It is not necessary to call during the time interval shown in the sample. Rather, the call can be made at a time convenient to the caller but as soon as possible after the designated time interval. For example, as suggested earlier, it might be desirable to call between the hours of 6:00 p.m. and 8:00 p.m., thus insuring that most people contacted will be at home. One procedure might be to select all of the individuals that are to be called concerning their availability throughout the workday Monday and call each of them on Monday evening. Similarly for Tuesday, Wednesday, etc. Another much less desirable procedure might be to wait until the end of the week and contact all of the individuals in the sample on Friday evening. There is sufficient flexibility in making the contact that the civil defense organization can select a procedure most suitable for their own needs, remembering that the longer the delay in sampling the less accuracy will be obtained in the responses. It is to be expected that certain of the telephone calls will not find the individuals sampled to be at home. In these cases, the calls must be repeated at a later time but as soon as possible. Once an individual has been contacted, the kinds of questions asked will determine the validity of the information that is obtained. The value of a respondent's "opinion" concerning his ability to report for muster or to his civil defense post will depend in large measure on his ability to evaluate the situation under conditions of emergency during the designated time period. Therefore, it is desirable to obtain relatively objective and quantitative information during the survey to assist the test administrator in evaluating the responses.

For instance, if a volunteer is simply asked if he could have made his post at from 3:15 to 3:30 p.m. the previous day, and he says "Yes," the test administrator has no way of knowing whether the response is even realistic. Whereas, if the volunteer's whereabouts at that time are determined, and the distances between that location, his home, and/or his civil defense post are (at least) estimated, his response can be evaluated by the test administrator. Such a technique should result in more realistic statements of availability as a result of the test survey.

It is to be anticipated that in some cases the individuals will simply not know if they could have gotten to their assigned duty post within the allotted time. This can occur, for example, when the individual is not at his normal place of business but not far enough away to be certain that he could not muster. These situations must be resolved by local judgment considering how far the individual is from his duty post, the kind of transportation available, if he will go directly to his post or go home first to get his family, equipment, etc., and any other factors which might influence the ability of the individual to muster for duty. The supporting information suggested above and included in the recommended "Interview content and format" contained on pages 83-84 will be of assistance in making these judgments.

If it is judged that an individual was in fact available for duty at the time interval in question, then an appropriate notation is made after his name as shown in Table 5. The illustration used here shows that of the 44 people sampled 41 of them were available on the day and at the time interval associated with their name. The availability of shelter managers is then computed to be 41 divided by 44 or .93. This means that about 93 per cent of the shelter managers would be available for duty if they were needed at any time during the weekdays between the hours of 0800 to 1700. A similar sample would have to be drawn and the procedure of contacting the individuals in the sample repeated to determine the availability of shelter managers during the evening hours. Also a third sample must be used to estimate availability during weekends and holidays.

One point of caution should be made. Once a sample has been selected and used to estimate availability, it cannot be used again at a later date but should be discarded. When it is necessary to remeasure availability a new sample should be selected and the entire procedure repeated, being careful that different points of entry be selected if the same tables of random numbers are used.

It was mentioned earlier in this report that contacting the individuals in certain operating groups by telephone can be prohibitively expensive or time

consuming. Under these conditions the individuals could be contacted via mail. It might be convenient for the civil defense organization to develop a standard form based on the format contained in Pages 83-84 to be printed on a self-addressed post card which then can be mailed to each individual in the sample. It is to be expected that all of the individuals contacted by mail will not respond. Cards get lost in the mail or inadvertently thrown away, etc. Therefore, when conducting a mail sample it is wise to increase the sample size by enough to replace the cards not returned. How much to increase sample size can only be determined from local experience but for the first mail sample it might be increased by at least 50 per cent. A sample, of course, cannot be too "large" because the larger it is the more accurate will be the estimate of availability.

A final caution should be noted in the evaluation of responses made to a mail sampling. Since there is no personal contact in a mail survey, there is no information concerning the attitude of the respondent in answering the questions. Therefore, a cover letter should accompany the inquiry explaining the importance of the survey and the necessity for accurate (conscientious)estimates. Also it should be kept in mind that those individuals who respond to the mail survey are probably the most interested and sincere members of the civil defense group. Therefore, it might be expected first that they would be more than likely "available," and if not in fact would feel it their obligation to be available and therefore consciously or unconsciously paint a more optimistic picture than is the case. The influence of both of these effects would be to increase the number of personnel who were apparently available at the selected time.

The preceding illustration was presented in terms of a procedure for administering what has been called in this memorandum the initial sample. The remaining part of this section will be devoted to discussing the use of the sequential sample plan.

Suppose now that a certain amount of time has passed since the availability of shelter managers was measured and it is desired to check whether or not the 93 per cent availability previously measured remains a valid estimate. This, of course, is the situation for which the sequential sampling plan was designed.

The procedure for selecting the sample for the sequential plan is identical to that for the initial sample. A list of time intervals as shown in Table 4 is required and a list of shelter managers as shown in Figure 14 is required. Also a data sheet as shown in Table 5 is required. The question remaining is how large a sample is needed and how should the data be utilized as they are collected?

It is known from the initial sample that shelter manager availability was 93 per cent and the question is: has this availability changed? Because availability was measured to be 93 per cent the chart of Figure 23 where "p" is equal to . 90 is used in the sequential plan. The appropriate chart from Figures 15 to 23 is selected as that whose "p" is closest to the estimated availability. For example, if the estimate of availability was . 68 then the chart of Figure 21 where "p" is . 70 would be selected for the sequential sampling plan.

The size of the sample required by the sequential plan cannot be stated in advance because each piece of data is used as it is collected. However, selecting the sample of time intervals and individuals to be contacted is easy to do; therefore, one might start with a listing of, say, 20 individuals and time intervals (or more) on the data sheet of Table 5. . The individuals are then called and as each is contacted, the number of "successes" (i. e. , those available) and the number sampled is plotted on a chart like the one shown in Figure 23. When a point corresponding to the number of successes and number sampled falls in the "accept" region, then sampling may be discontinued and the availability estimated from the initial sample may be accepted as a valid measure. On the other hand, if a point falls in the "reject" region, the estimate of availability must be rejected and a new initial sample collected. Finally, if the points fall in the band (or bands) labeled "continue sampling" then it is not known whether the availability can be accepted or rejected and sampling must continue.

If the data collected under the sequential plan were as shown in Table 5, it can be seen that less than fourteen shelter managers would have had to be contacted before the estimate of 93 per cent availability could have been accepted.

The sequential sampling plan does not have to be used, of course. It is perfectly acceptable to remeasure the availability of any operating group by taking a new sample using the initial sampling plan. It is doubtful, for example, that the sequential sampling plan is of much value in checking estimates when the sample is to be collected by mail; therefore, repeated applications of the initial sample should be used to perform such checks.

It is recommended that the summarized results of samples taken be retained by the test administrator. In this way he can compare his personnel availability over time and he will have the data to indicate changes in availability as a function of the time of year and other such variables.

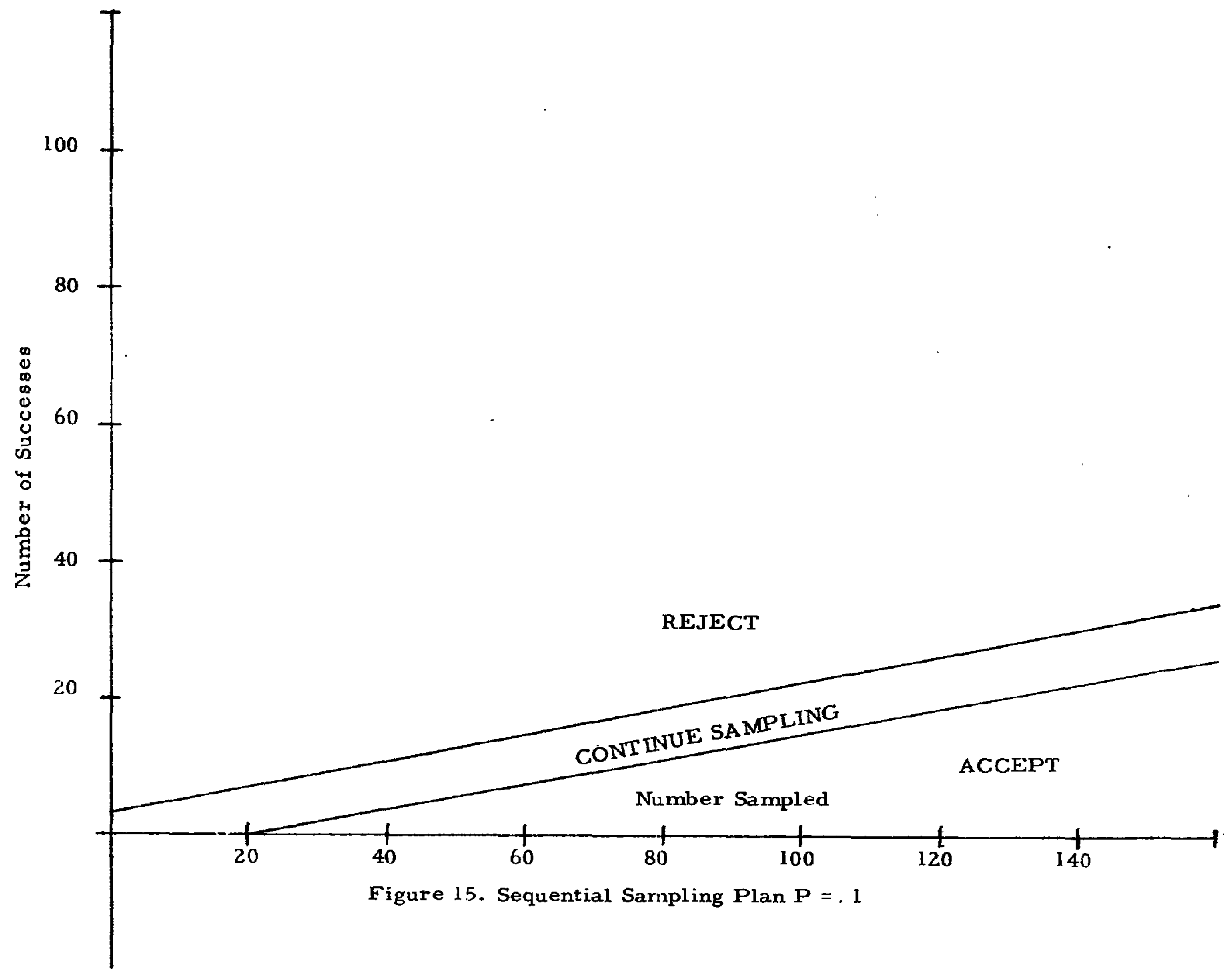


Figure 15. Sequential Sampling Plan P = . 1

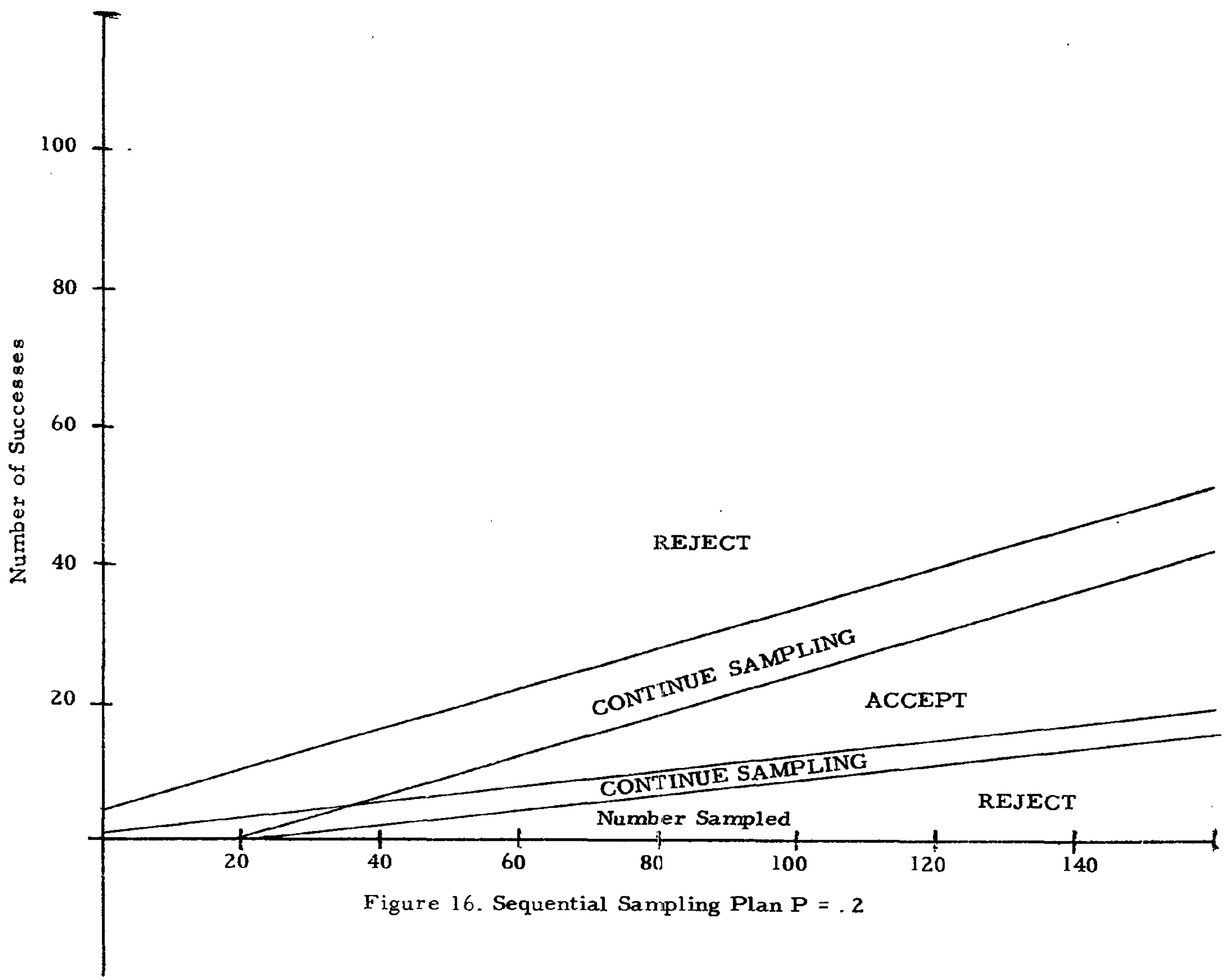


Figure 16. Sequential Sampling Plan P = .2

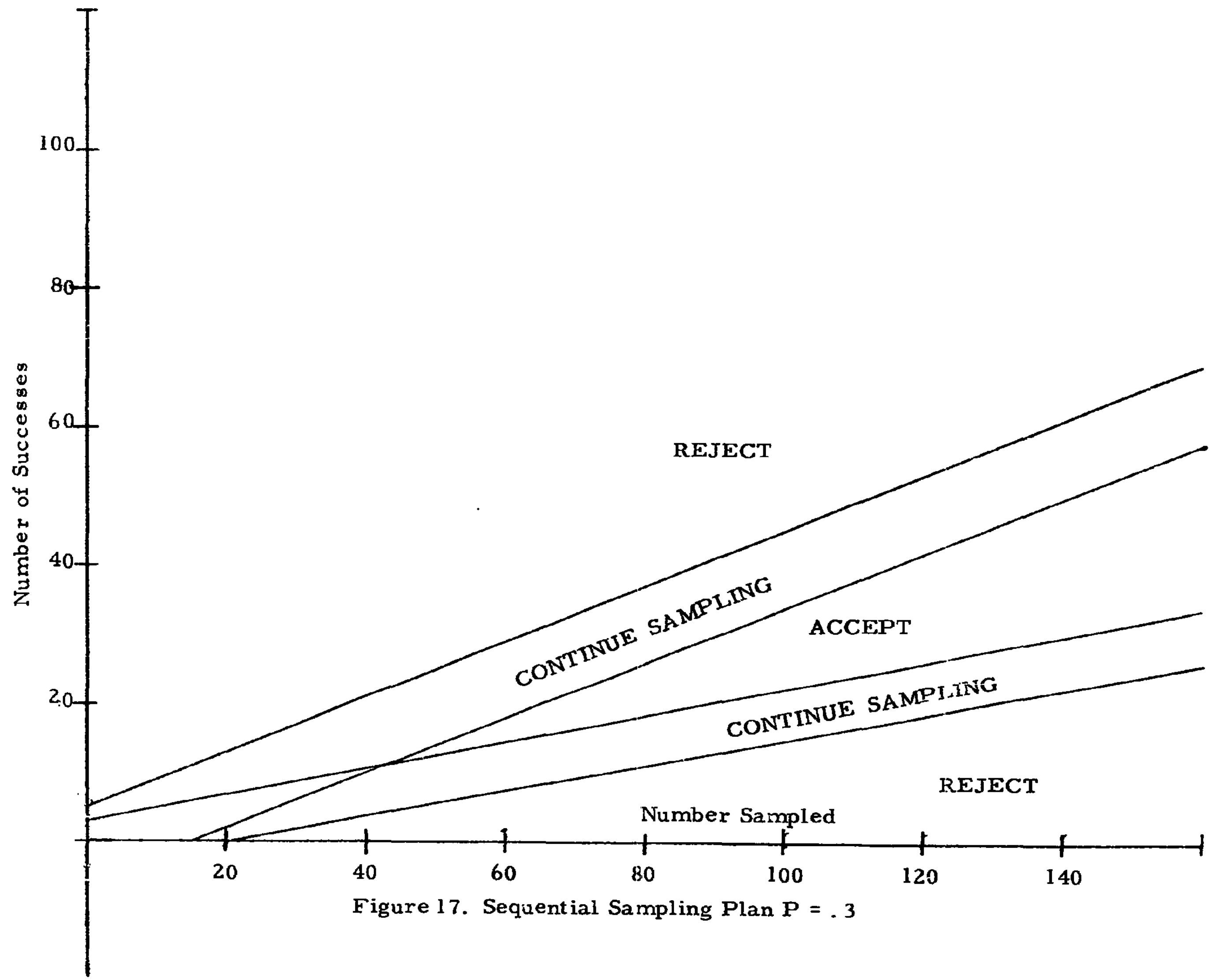


Figure 17. Sequential Sampling Plan P = . 3

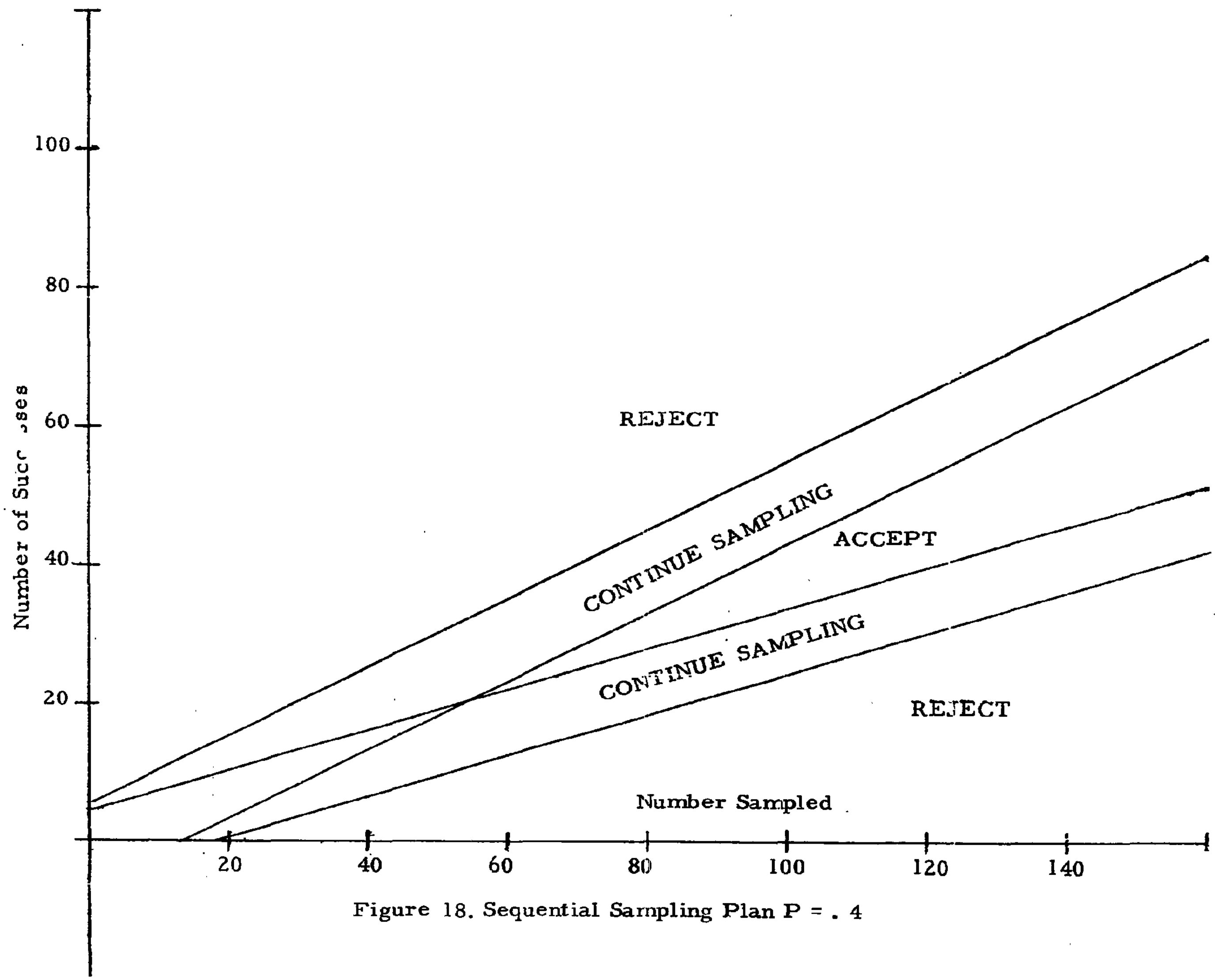


Figure 18. Sequential Sampling Plan P = . 4

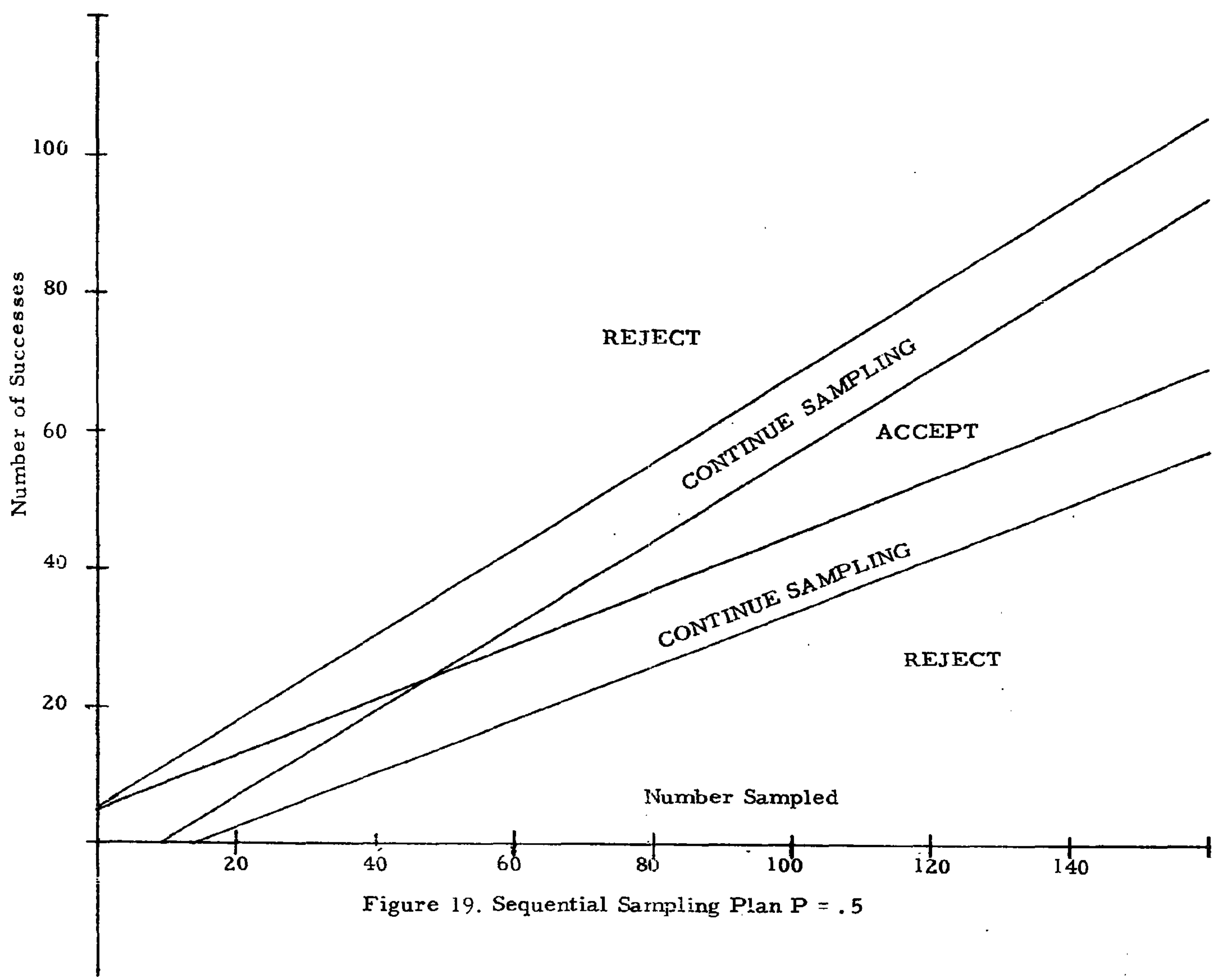


Figure 19. Sequential Sampling Plan P = .5

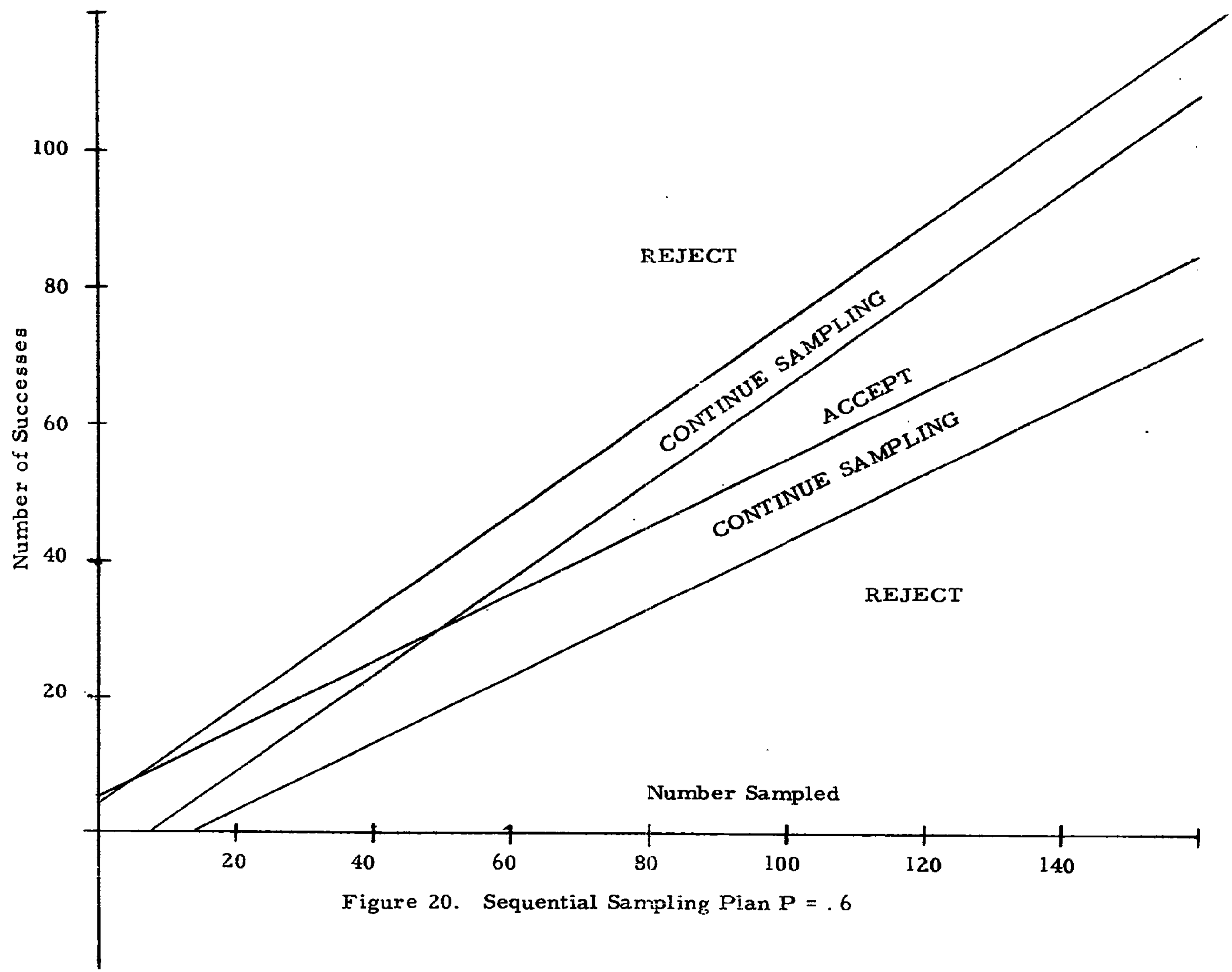


Figure 20. Sequential Sampling Plan P = .6

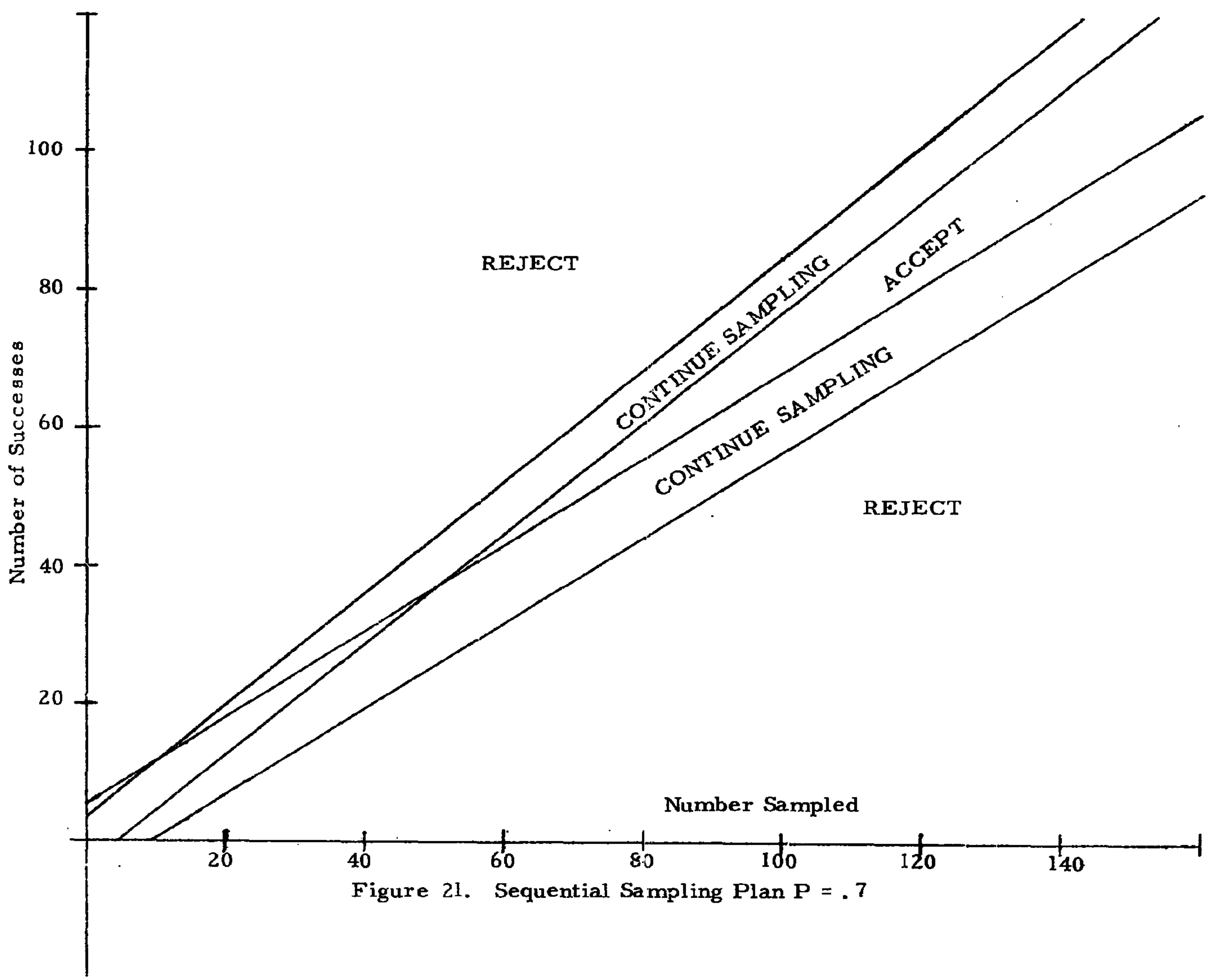


Figure 21. Sequential Sampling Plan P = .7

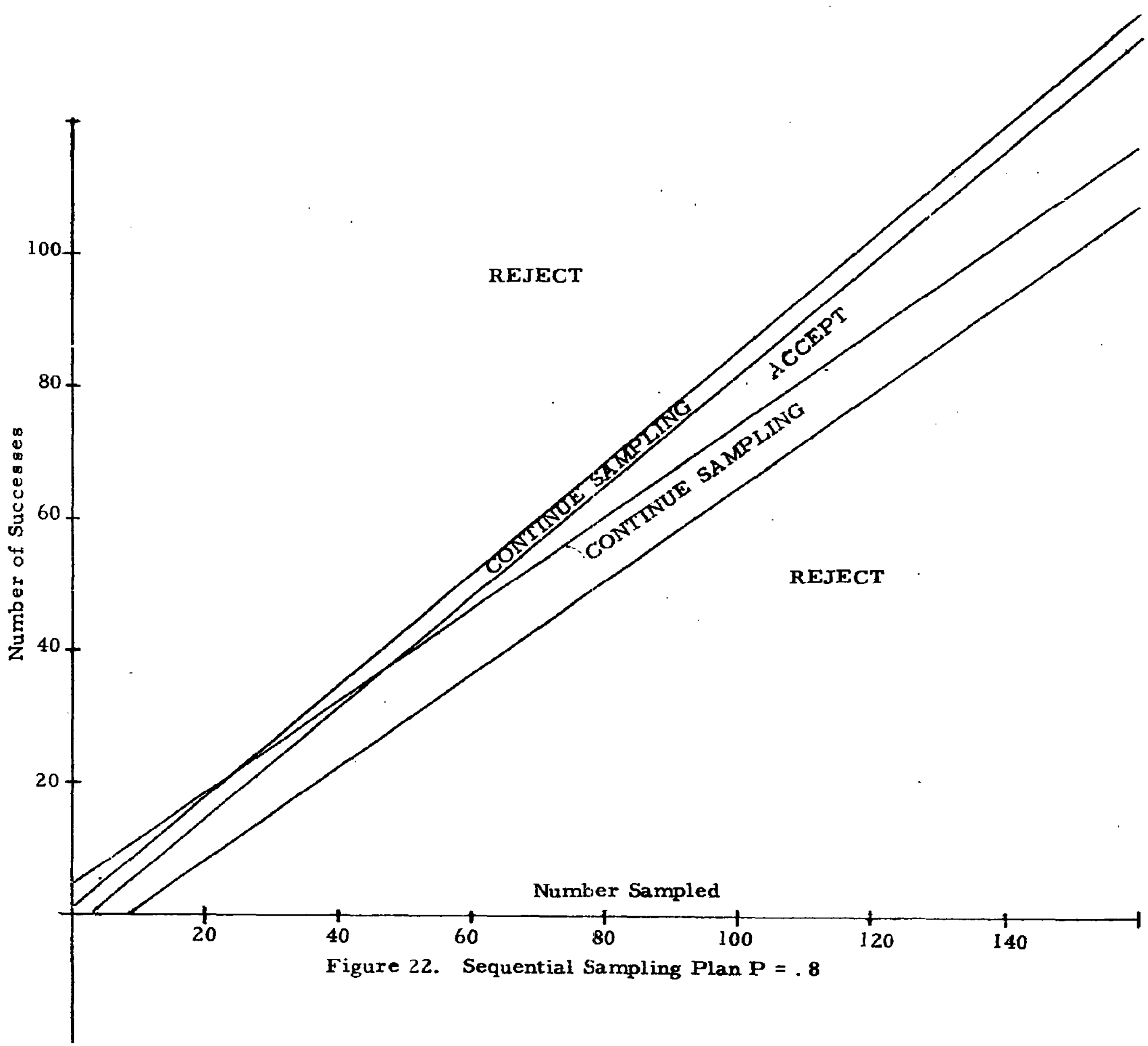


Figure 22. Sequential Sampling Plan P = .8

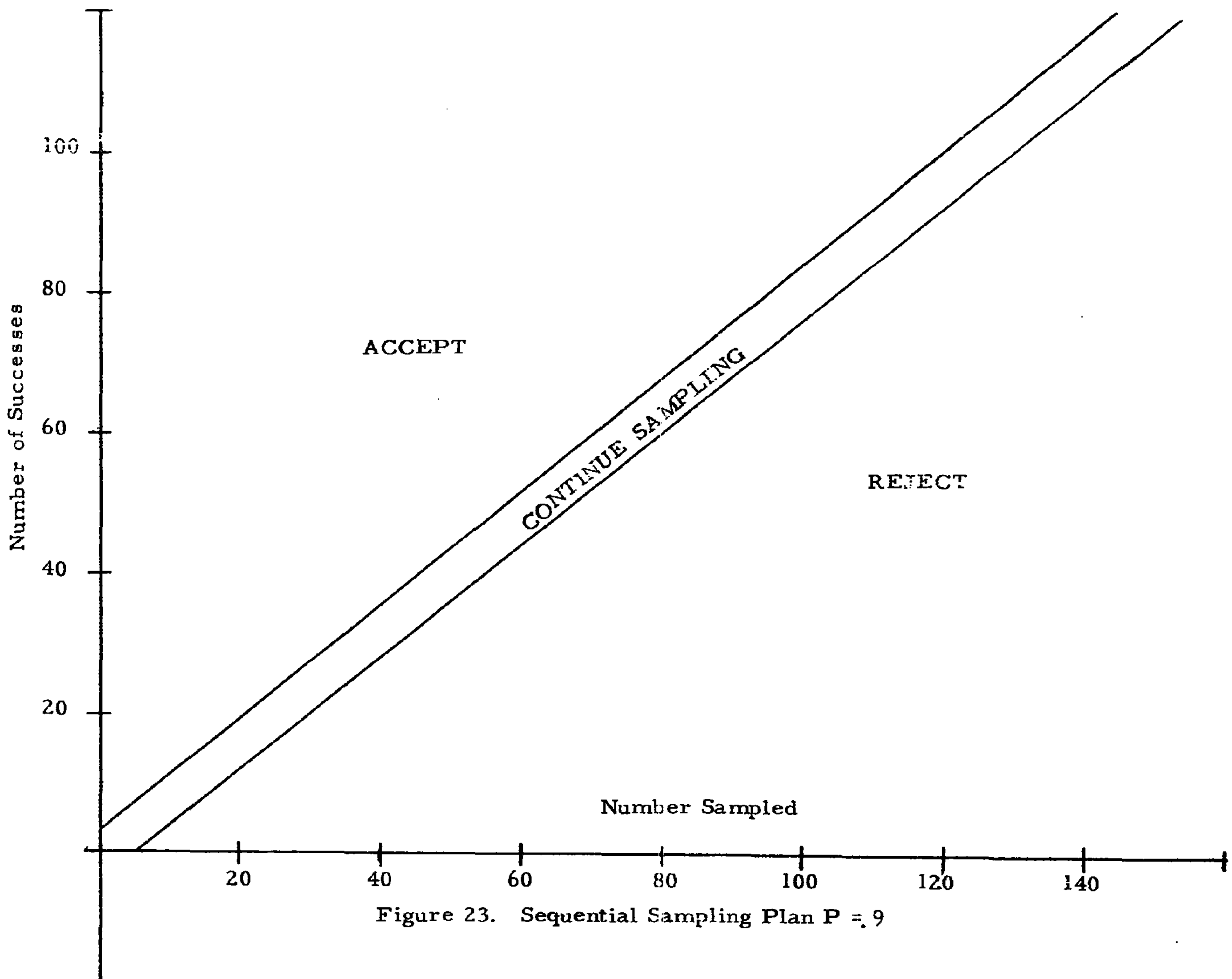


Figure 23. Sequential Sampling Plan P = .9

4. Selection of a Random Sample

The importance of randomly selecting the sample of individuals to be contacted as part of the muster plan test has been emphasized previously. The purpose of this section is to discuss the mechanics of random selection.

It must be clearly understood that random selection must be done with a mechanical aid or procedure. In other words, the randomness of a sample cannot be trusted if it is chosen on the basis of intuition.

The discussion presented in this section will be limited to the use of random numbers in sample selection. It is suggested that the test administrator procure a table of random numbers. It is recognized that such a table may not be easily acquired by the administrator, therefore, a mechanical procedure is described which will enable him to generate numbers randomly. The mechanical procedure is, however, somewhat more laborious and time consuming to use than a table of random numbers.

A table of random numbers is usually presented as columns of five-digit numbers. An excerpt from such a table is as shown below.

61777	25417
04192	63531
76036	84821
96472	23179
92388	58241
.	.
.	.
.	.
.	.

It first must be determined how many digits are required in the random number to be used in sample selection. If the population from which the sample is to be selected is 10 or less, a single digit random number is required. If the population is 100 or less, a two-digit number is needed. A population of 1000 or less requires a three-digit number, and so forth. For example, in the illustration presented in the body of this memorandum, the population of shelter managers was 17, thus requiring two-digit numbers, and the population of time intervals was 180, which required three-digit numbers.

If two-digit numbers are required then merely select any two columns of one-digit numbers from the random number table. The first two columns of one digit numbers from the table excerpt shown above might be selected or 61, 04, 76, 96, 92...... One could just as well have selected the first and third columns from the first set of five-digit numbers or 67, 01, 70, 94, 93... It is in this manner that a series of one, two, three, etc., digit random numbers are generated.

Returning now to the example of shelter manager sampling, it will be noted that there are only 17 shelter managers in the population. The managers are listed alphabetically and numbered. When a random number, taken from the table of random numbers, falls between 01 to 17 it is matched with the number associated with the shelter manager and the name so designated becomes part of the sample. All random numbers greater than 17 are not used in selecting the sample.

One word of caution that will be mentioned although it is perhaps obvious. If a second sample of shelter managers is to be selected the same random numbers cannot be used again. This merely means that in using the table of random numbers start at a different page in the book.

A technique that can be used to generate random numbers in the absence of a table will now be discussed. This procedure is very simple and consists of marking equally shaped and weighted objects (e.g., pasteboard cards) with a single digit. Ten such cards are required corresponding to numbers from 0 to 9. These objects are placed in a suitable container and thoroughly mixed. If a one digit number is required a single object is drawn from the container which provides the necessary one-digit random number. If a two digit number is required two drawings are made from the container but the first drawing must be replaced before the second one is made. In this manner a series of random numbers are generated. These numbers are used in the same manner as numbers selected from a table of random numbers.

5. Technical Development of the Sequential Sampling Plan

The procedure developed for this test is: (1) to select a sample of the population of civil defense personnel, (2) telephone contact this sample and (3) determine what proportion of them could get to their assigned location within a predetermined time limit. Since there is a dichotomy in the possible responses that an individual can make (i. e., either he can or he cannot reach his assigned position within the time limits) the distribution of responses will follow the binomial distribution. Therefore, it has been decided to initially take a rather large sample and to determine the proportion of civil defense personnel that can get to their assigned locations within a specific time. This proportion, P', is the probability that any individual in the entire population can get to his assigned location. In this section a test is developed to determine with a minimum sampling technique when this probability has changed significantly. The points at which the variance about P' is considered significant are values which are entirely dependent on the logical structure of the problem. These values describe an interval about P' in which new value of the mean can fall without affecting the original estimate of the mean. For example, assume that the original estimate of the mean was found to be .7, while a significant deviation from this mean was set at plus or minus .1. This would mean that any observation falling between .8 and .6 would be interpreted as being a variation of no consequence, and, therefore, not affecting the original estimate of the mean, $P' = .7$. These upper and lower boundaries for P' can be denoted by P^* and P^{**} respectively.

a. Formulation of the Problem

Let x be the random variable which can take on only the values of zero and one (i. e., the dichotomy of whether or not the individual can reach his assigned location within the specific time period). Denote by P the (unknown) probability that x takes on the value 1. We shall deal first with the problem of testing a hypothesis that P does not exceed the predetermined value of P^*.

Assign the value zero to any individual that cannot reach his assigned location and value one to any individual who can reach his assigned location. Let P denote the unknown proportion of the individuals within the entire population who can reach their assigned locations. Then the result, x, of the

inspection of individuals drawn at random from the entire population can take only the values one and zero, with probabilities P and 1 - P, respectively. Since a value P* has been specified, it is now possible to accept the fact that the mean has not increased whenever P is less than or equal to P* and we would like to reject the hypothesis that the mean has not changed whenever P is greater than P*. Thus, the problem of deciding whether the estimated mean of the population is to be accepted or rejected on the basis of a random sample may be formulated as the problem of testing the hypothesis $P \leq P^*$ against the alternative hypothesis that $P > P^*$.

b. Tolerated Risks of Making Wrong Decisions

Any sampling plan which does not provide for complete inspection of the population may lead to a wrong decision. That is, we may accept the fact that the mean has not shifted up when $P > P^*$ or we may reject it when in fact $P \leq P^*$. Since a complete inspection in this situation would be both time consuming and costly, a set of tolerable risks of making a wrong decision will have to be determined. Inorder to determine the proper sampling plan, it is necessary to state the maximum risk of wrong decisions that can be tolerated.

When P is equal to P* it does not make much difference whether the hypothesis is accepted or not. When P is greater than P*, we would prefer to reject the hypothesis and this preference increases with increasing values of P. For P less than P* we would prefer to accept the hypothesis and this preference increases with decreasing values of P. If P is only slightly above P*, the preference for rejection is only slight and acceptance of the hypothesis will not be regarded as an error of practical consequence. Similarly, if P is only slightly below P*, rejection of the hypothesis is not a serious error. Following this reasoning, it should be possible to specify two values P_0 and P_1, P_0 below P* and P_1 above P*, such that acceptance of the hypothesis is regarded as an error of practical consequence if and only if P is greater than or equal to P_1, and rejection of the hypothesis is regarded as an error of practical importance if and only if P is less than or equal to P_0.

After the two values P_0 and P_1 have been chosen, the tolerable risks of making wrong decisions can be formulated as follows: the probability of rejecting the hypothesis should not exceed some small preassigned value, alpha, whenever P is less than or equal to P_0, and the probability of accepting the hypothesis should not exceed some small preassigned value, beta, whenever P is greater than or equal to P_1.

Thus, the tolerated risks are characterized by four numbers, P_0, P_1, alpha, and beta. A choice of these four quantities is not a statistical problem. They should be selected on the basis of the practical considerations which are relevant to a test on mustering capabilities.

c. <u>Derivation of the Algebraic Formulas of the Test Criteria</u>

The sampling plan satisfying the conditions that the probability of rejecting the hypothesis does not exceed alpha whenever $P \leq P_0$, and the probability of accepting the hypothesis does not exceed beta whenever $P \geq P_1$, is given by the sequential probability ratio test of strength (alpha, beta) for testing the hypothesis $P = P_0$ against the hypothesis $P = P_1$. This test is defined as follows: Let $x_i = 1$ if the i^{th} individual inspected can reach his assigned location, and $x_i = 0$ otherwise.

If P denotes the portion of successes in the population, the probability of obtaining a sample with a mean equal to the originally observed mean is:

$$P^{d_m} (1 - P)^{m-d_m} \qquad (1)$$

Where d_m denotes the number of successes in the first m individuals inspected. Under the hypothesis that $P = P_1$ the probabilities become equal to

$$P_{d_m} = P_1^{d_m} (1-P_1)^{m-d_m} \qquad (2)$$

and under the hypothesis that $P = P_0$ the probability becomes equal to

$$P_{0m} = P_0^{d_m} (1-P_0)^{m-d_m} \qquad (3)$$

The sequential probability ratio test is carried out as follows. At the inspection of the m^{th} individual for <u>each</u> positive integral value of m, we compute

$$\log \frac{P_{1m}}{P_{0m}} = d_m \log \frac{P_1}{P_0} + (m-d_m) \log \frac{1-P_1}{1-P_0} \qquad (4)$$

Inspection is continued as long as

$$\log \frac{\beta}{1-\alpha} < \frac{\log P_{1m}}{P_{0m}} < \log \frac{1-\beta}{\alpha} \qquad (5)$$

Inspection is terminated the first time that equation (5) does not hold. If at this final stage we have

$$\log \frac{P_{1m}}{P_{0m}} \geq \log \frac{1-\beta}{\alpha} \qquad (6)$$

the hypothesis is rejected, and if

$$\log \frac{P_{1m}}{P_{0m}} \leq \log \frac{\beta}{1-\alpha} \tag{7}$$

the hypothesis is accepted. The above inequalities can be replaced with the following inequalities:

$$d_m \geq \frac{\log \frac{1-\beta}{\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} + m \frac{\log \frac{1-P_0}{1-P_1}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{8}$$

$$d_m \leq \frac{\log \frac{\beta}{1-\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} + m \frac{\log \frac{1-P_0}{1-P_1}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{9}$$

For each value of m we shall denote the right-hand member of equation (9) by a_m and call it the acceptance number. Similarly, we shall denote the right-hand member of equation 8 by r_m and call it the rejection number. On the basis of the inequalities in (8) and (9) the sequential probability ratio test is carried out as follows. At each stage of the inspection we compute the acceptance number a_m and the rejection number r_m. Inspection is continued as long as $a_m < d_m < r_m$. The first time that d_m does not lie between the acceptance and rejection numbers, inspection is terminated. If $d_m \geq r_m$ the hypothesis is rejected, and if $d_m \leq a_m$ the hypothesis is accepted.

d. Tabular Procedure for Carrying out the Test

The acceptance number

$$a_m = \frac{\log \frac{\beta}{1-\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} + m \frac{\log \frac{1-P_0}{1-P_1}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{10}$$

and the rejection number

$$r_m = \frac{\log \frac{1-\beta}{\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} + m \frac{\log \frac{1-P_0}{1-P_1}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{11}$$

depend only on the quantities P_0, P_1, alpha and beta. Thus, they can be computed and tabulated before inspection starts. If a_m is not an integer, we may replace it by the largest integer $<$ a_m. Similarly, if r_m is not an integer, we may replace it by the smallest integer $>$ r_m.

e. Graphical Procedure for Carrying Out the Test

The test procedure can also be carried out graphically. The number m of observations is measured along the horizontal axis, and the number d_m of successes along the vertical axis. The points (m, a_m) lie on a straight line L_o since a_m is a linear function of m. Similarly, the points (m, r_m) lie on a straight line L_1. The intercept of L_o is given by

$$h_o = \frac{\log \frac{\beta}{1-\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{12}$$

and the intercept of L_1 is given by

$$h_1 = \frac{\log \frac{1-\beta}{\alpha}}{\log \frac{P_1}{P_0} - \log \frac{1-P_1}{1-P_0}} \tag{13}$$

The lines L_o and L_1 are parallel and the common slope is equal to

$$S = \frac{\log \dfrac{1 - P_0}{1 - P_1}}{\log \dfrac{P_1}{P_0} - \log \dfrac{1 - P_1}{1 - P_0}} \qquad (14)$$

The two straight lines L_o and L_1 can be drawn before inspection starts. The points (m, d_m) are plotted as inspection goes on. Inspection continues as long as the point (m, d_m) lies between the lines L_o and L_1. If (m, d_m) lies on L_o or below, the hypothesis is accepted. If (m, d_m) lies on L_1 or above, the hypothesis is rejected.

Figure 24 is an example of the graphical procedure.

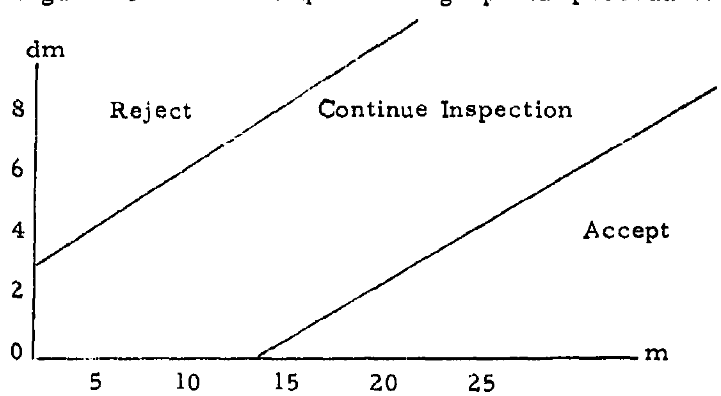


Figure 24. .

f. Two-Sided Tests

Up to this point only the test for detecting an upward shift in the value of P has been examined. Since it is highly probable that Civil Defense will be equally interested in downward shifts in the mean, a test for this contingency has also been developed. This second test relies on the same reasoning as the test for upward shifts in the mean, except that the hypothesis is restated as follows: accept the fact that the mean has not changed whenever $P \geq P^{**}$ and reject this statement whenever $P < P^{**}$. Again it is necessary to select the four values of alpha, beta, P_1 and P_o which relate to errors of significant consequence around P^{**}. The remainder of the procedure is

exactly the same as for detecting upward shifts in the mean. When it is convenient to administer both of these tests simultaneously, the graphical method should be used. Figure 25 is an example of a typical graph containing both of the tests.

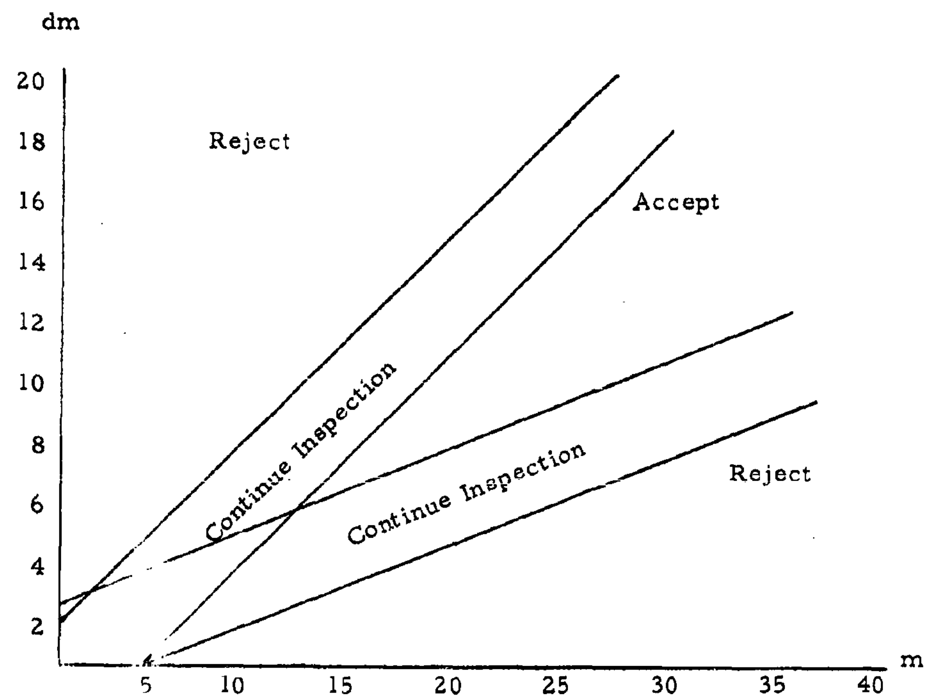


Figure 25..

g. Observations Taken in Groups

For practical reasons it may sometimes be preferable to take observations in groups rather than singly. That is, the test procedure is carried on as follows. A group g_1 consisting of v units is drawn from the population. If the number of successes, d_v, in this group g_1 falls into the acceptance region designated on the appropriate graph, inspection terminates with the acceptance of the hypothesis that the mean has not changed. If d_v falls in one of the rejection regions, inspection terminates with the rejection of the hypothesis. If d_v falls in a continue inspection region a

second group g_2 of v units is drawn. This process is continued until rejection or acceptance of the hypothesis is decided. Thus, when the observations are taken in groups of v units, the number of d_v of successes found is compared with the corresponding acceptance and rejection lines only for m = v, 2v, 3v, ... , etc.

h. Truncation of the Test Procedure

The sequential sampling plan does not provide any definite upper bound for the number of individuals to be inspected. Any large value of n is possible, but the probability is small that n will exceed twice or three times its expected value.* It may be desirable to set a definite upper bound n_0 for n. This can be done by truncating the sequential process at $n = n_0$. That is to say, the process is terminated at $n = n_0$ even if the regular sequential rule does not lead to a final decision at that point. The recommended procedure for selecting a value for n_0 is to equate it to the value of n used in the initial sample for the appropriate P' being investigated. This procedure will allow the test administrator to recalculate immediately the estimated mean.

This truncation process will slightly affect the values of alpha and beta, however since n_0 will be large, this effect can be considered as being negligible.

*The expected value of n can be computed as follows:

$$E(n) = \frac{-\left(\log \dfrac{\beta}{1-\alpha}\right)\left(\log \dfrac{1-\beta}{\alpha}\right)}{\log \dfrac{P_1}{P_0} \qquad \log \dfrac{1-P_0}{1-P_1}} \tag{15}$$

6. Illustrative Guide to Conducting the Telephone Interview Part of the Muster Plan Test

General Instructions

- When you telephone the team member, ask for him by name. If the party is not at home, don't ask the questions of another member of the family; merely state that you will call back at another time.
- When asking the survey questions, do not suggest how the questions should be answered. You may repeat a question if necessary. You will have to decide what box should be checked for each item.
- Fill out the identifying information, the survey time period and date before you make the call.

a. Identifying Information — Date of Survey:

1. Name ________________ (last and initials) — 2. OCD Activity ____________

3. Time period sampled:

a. hour ________ a.m./p.m. — c. Weekday______ Weekend______ Holiday______

b. date ________ 196___

4. Weather ____________________

b. Muster Plan Survey

1. Please tell me where you were at______ to_____ on_____ (3 a and b above)
(time) (date)

2. Would you tell me what you were doing at that time? (e.g., working, travel, errand). ________________________________

3. Was your car immediately available to you at that time? __________

As questions 4 through 7 only if individual was not at home during test period.

4. If your car was not with you, how long would it have taken to get it (or get to it)? ____________

5. How far was it to your home from where you were? ____________

6. How long would it have taken you to drive home from there in an emergency? ____________

7. How long would it take you to walk home from there? ____________

8. How far is it to your CD station from where you were? ____________ (mi.)

9. How long would it take you to drive to your CD station directly from where you were in an emergency? ____________

10. How long would it take you to walk to your CD station directly from there? ____________

11. Where is your CD equipment located?

    a. At home____ c. At CD station_____

    b. In your car____ d. None required_____

c. Availability

This individual could have reached his CD station or muster point within the allowable time(_____min.) Yes_____ No_______.

D. Detailed Description Of A Test For Measuring the Damage Assessment Capability At State and Regional Civil Defense Centers

1. Introduction

One of the primary functions assigned to Civil Defense is damage assessment following a nuclear attack on this country. The purpose of this section of Chapter II is to describe a test designed to measure the ability of Civil Defense to perform this function.

Damage assessment as it is to be performed by Civil Defense involves two steps. Step one consists of the collection of fragmentary reports from communities in the vicinity of nuclear explosions. These reports will contain estimates of ground zero and burst height as well as observations of initial thermal and blast effects. Literally hundreds of messages, many containing conflicting bits of information, may have to be manually evaluated by control center personnel for the purpose of making estimates of ground zero, burst height and weapon yield for each detonation. Current Civil Defense plans call for this task to be performed by state control centers with regional centers having the back up capability for performing the same task. The second step involves the transmission of these estimates to a central data processing facility. Here pre-programmed computers utilizing existing peacetime statistics covering population densities, food stockpile locations, manufacturing facility locations, etc., will be fed these estimates of weapon yield, ground zero and burst height. The outputs of these computers will be estimates of casualties, remaining resources, etc.

Both of these steps involve the evaluation of data for the purpose of making certain estimates. However, the processes by which these evaluations are made are vastly different. The successful accomplishment of step one depends heavily on the ability of people to sift through a myriad of conflicting reports and make manual estimates of certain parameters. Step two simply involves feeding the results of step one into a pre-programmed computer. Because of this difference in the nature of these two processes it is clear that step one, the manual estimation of ground zero, burst height, and weapon yield by state and regional control centers is the only area of damage assessment for which the development of a test is warranted.

The remainder of this section is devoted to a detailed description of the specific requirements and nature of the damage assessment test, the procedures involved in administering and scoring it, and an objective evaluation of the advantages and shortcomings of the test. Part 2 includes

a description of the requirements of the test as well as the development of the test. Part 3 outlines the step-by-step procedures required to run the test. The information contained therein is presented in sufficient detail to allow civil defense personnel to actually administer the test to any control center group. Part 4 briefly discusses a method for scoring the test results, while Part 5 discusses the degree to which the test meets the requirements set forth in Part 2.

2. Development of a Test

a. Requirements

The unique nature of state and regional control center damage assessment operations requires that the test incorporate certain special features. These features are listed as follows and are in addition to the primary function of measuring a control center's damage assessment capability.

1) It should be possible to administer the test to individual state and regional control centers as well as to groups of such centers, without requiring the participation of outside agencies or communications systems.

2) It should be possible to repeatedly administer the test to the same personnel without significantly decreasing the value of the test as a measure of their performance.

3) The test should be useful as a diagnostic tool, pointing up areas requiring further training.

4) The test should require a minimum of time to run and be simple to administer and score.

5) The requirement for special equipment and for special training of control center personnel should be kept to a minimum.

Obviously, no test can fully incorporate all of these features. However, in designing the test every effort has been made to take these notions into account and to the maximum extent possible, incorporate them into the test.

b. Test Description

1) General

The following test is based on the simulation of a number of sets of messages, each set describing the initial effects of a number of different size nuclear explosions as might be observed by people at varying distances and directions from ground zero, between the time of detonation to the time these people are able to enter a shelter and report their observations for transmittal to a state or regional control center. These messages include information on initial thermal and blast effects as well as sightings concerned with ground zero and burst height. They are fed randomly to the control center group being tested at predetermined time intervals and over the communication links available to the particular facility. This information combined with a set of maps covering the area of interest and a basic knowledge of nuclear weapons effects is sufficient to enable the control center to develop estimates of ground zero, burst height and weapon yield for each nuclear detonation. The degree to which these estimates agree with the actual values of these variables is taken as the measure of the performance of the damage assessment function.

2) Weapon Sizes Used in the Test

It is neither feasible nor of significant value to develop a test covering the continuum of nuclear weapon sizes that might be used against the various target areas in this country. The following discrete group of eight weapon sizes has been chosen so as to represent the range of weapon yields most likely to be used.

A control center that can identify the yield of these bombs from the data supplied, should be able to identify any size weapon and consequently could be considered as "adequately" trained. Table 6 indicates the weapon yields chosen. Weapon sizes have been deliberately kept as "odd" numbers so as to counter the tendency of many people to think of these bombs as neat packages of say 10 or 20 megaton increments in size.

The terms "air" and "ground" burst are as defined in "The Effects of Nuclear Weapons," 1962, and refer to burst altitudes which maximize certain types of damage over the largest areas. Obviously, weapons can be exploded at other than these altitudes with resulting changes in the damage-range relationship. These cases have not been treated here.

Table 6

Weapon Yield and Type of Burst Used In Test

Weapon Yield	Type of Burst
120 kiloton	ground
650 kiloton	ground
1.8 megaton	ground
4.2 megaton	air
8.4 megaton	ground
13 megaton	ground
22 megaton	ground
34 megaton	air

As long as a detonation occurs within a few thousand feet of its "optiumum" altitude, no significant error is introduced in the calculation of weapon yield by assuming that detonation actually occurred at the ideal elevation. For significant deviations from optimum burst conditions additional examples will have to be developed.

3) Categorization of Damage Caused by a Nuclear Explosion

The detonation of a nuclear device produces certain kinds of damage due to heat and blast at varying distances from ground zero. These classes of damage remain constant; however, the distances from ground zero at which these different types of damage occur vary as a function of the yield of the device and its burst altitude. For example, the explosion of a nuclear device results in a heat wave. This heat wave produces first, second and third degree burns at certain distances from ground zero. Any size bomb will produce these same effects. However, the distances from ground zero where these effects are felt vary mainly as a function of weapon yield and burst height.

A vast amount of information has been documented on the weapon yield and burst height as a function of damage to personnel, materials, equipment and facilities. However, only a small portion of these data is the kind of information the average citizen is likely to see and remember in his hasty journey to a shelter following the attack. In general, it is upon these reports that control centers will be forced to base their initial estimates concerning weapon yield, ground zero and burst height. Those weapon effects that the layman is most likely to observe and remember are listed in Table 7. Bomb sizes and weapon effects as a function of distance from ground zero are listed in Table 8.

As an aid in developing the test it is convenient to represent the damage resulting from each of these bombs in the form of a damage profile such as that shown in Figure 26 for the 13 megaton ground burst. Damage profiles for all eight weapon yields listed in Table 6 are presented in Appendix A, of a separate technical memorandum entitled "Operational Test for the Damage Assessment Function of State and Regional Civil Defense Control Centers" submitted to the Office of Civil Defense November 28, 1962. These profiles show the ranges of distances within which the various weapons effects take place. A comparison between this profile in Figure 26 and the weapons effects for the 13 megaton bomb in Table 8 indicates that the profile consolidates some of the boundary areas (of these effects) where these boundaries fall close to each other. For example from Table 8 it is seen that for a 13 megaton ground burst the category of "severe damage to woodframe houses" occurs between 7.4 and 8.6 miles from ground zero. However, the damage profile in Figure 26 shows the range for this damage to be 7.4 to 9.6 miles. This consolidation reduces the likelihood that two or more combinations of weapons effects and range will fall so close to one another as to be indistinguishable by someone taking the test. No significant error is introduced by this procedure.

Table 7

Weapon Effects Likely to be Observed by the Average Citizen On His Way to a Shelter Immediately Following a Nuclear Explosion

1. Whether people have received third degree burns.
2. Whether people have received second degree burns.
3. Whether people have received first degree burns.
4. Whether people have received no burns.
5. Whether most windows are broken (more than 75%).
6. Whether only some windows are broken (between 25% and 75%).
7. Whether only a few windows are broken (less than 25%).
8. Whether woodframe private dwellings have been blown down.
9. Whether woodframe private dwellings have been severely damaged (roofs torn off, walls askew).
10. Whether woodframe private dwellings have received minor damage (shingles and doors blown off).
11. Whether woodframe houses have received little damage (windows broken, shutters off, TV antenna down).
12. Whether no damage to woodframe houses has occurred (other than broken windows).
13. Whether most trees and utility poles have been blown down (more than 75%).
14. Whether some trees and utility poles have been blown down (less than 75%).
15. Whether only branches and leaves but no trees or utility poles are down.
16. Whether a large number of fires are burning (one fire per building or more).
17. Whether some fires are burning (less than one fire per building).
18. Whether no fires are burning.
19. Whether many people are cut by flying glass (more than 75%).
20. Whether some people are cut by flying glass (less than 75%).
21. Whether no one is cut by flying glass.

Table 8
Weapons Effects and Distances from Ground Zero as a Function of Weapon Yield

Weapon Effects	Bomb Size							
	Ground 120K	Ground 650K	Ground 1.8M	Air 4.2M	Ground 8.4M	Ground 13M	Ground 22M	Air 34M
Third degree burns	-	< 5.5	< 8.0	< 14	< 16	< 19	< 21	< 32
Second degree burns	< 3.7	5.5-7.5	8.0-11.3	14-18	16-21	19-24	21-29	32-38
First degree burns	3.7-4.9	7.5-10	11.3-16	18-26	21-30	24-37	29-45	38-50
No burns	> 4.9	> 10	> 16	> 26	> 30	> 37	> 45	> 50
Most windows broken (> 75%) > 1 psi	< 3.7	< 6.4	< 9	< 22	< 15	< 19	< 21	< 44
Some windows broken (25%-75%).1-1 psi	3.7-24	6.4-42	9-58	22-	15-98	19-120	21-140	44-
Few windows broken (< 25%) < .1 psi	> 24	> 42	> 58		> 98	>120	> 140	
Woodframe houses completely blown down > 4 psi	< 1.55	< 2.7	< 3.8	< 8.2	< 6.4	< 7.4	< 8.8	< 16.4
Severe damage to woodframe houses 3-4 psi	1.55-1.8	2.7-3.2	3.8-4.5	8.2-10	6.4-7.5	7.4-8.6	8.8-10.3	16.4-20
Minor damage to woodframe houses 1.5-3 psi	1.8-2.75	3.2-4.8	4.5-6.8	10-16	7.5-11.6	8.6-13.3	10.3-16	20-32.5
Little damage to woodframe houses 1-1.5 psi	2.75-3.6	4.8-6.4	6.8-9	16-22	11.6-15	13.3-17.4	16-21	32.5-44
Most trees and utility poles down (>75%) > 4 psi	< 1.55	< 2.7	< 3.8	< 8.2	< 6.4	< 7.4	< 8.8	< 16.4
Some trees and utility poles down (< 75%) 2.5-4psi	1.55-2.1	2.7-3.6	3.8-5	8.2-11.5	6.4-8.5	7.4-9.6	8.8-11.5	16.4-22
Some branches but no utility poles or trees down 1.5-2.5 psi	2.1-2.75	3.6-4.8	5-6.8	11.5-16	8.5-11.5	9.6-13.3	11.5-16	22-32.5
Large number of fires (at least one/building)	< 2.6	< 5.5	< 10	< 15	< 14.4	< 16.8	< 20	< 35
Some fires (less than one fire/building)	2.6-4	5.5-8.8	10-15.5	15-21	14.4-23	16.8-26.4	20-32	35-45
No fires	> 4	> 8.8	> 15.5	> 21	> 23	> 26.4	> 32	> 45
Many hurt by flying glass (>75%) vel.> 250 ft/sec.	< 1.3	< 2.6	< 3.3	< 6.8	< 5.7	< 6.5	< 7.6	< 14.2
Some people hurt by flying glass (< 75%) vel. 100-250 ft/sec.	1.3-2.1	2.6-3.6	3.3-5.4	6.8-12.5	5.7-9.3	6.5-11	7.6-12.8	14.2-26
None hurt by flying glass velocity<100 ft/sec.	> 2.1	> 3.6	> 5.4	> 12.5	> 9.3	> 11	> 12.8	> 26

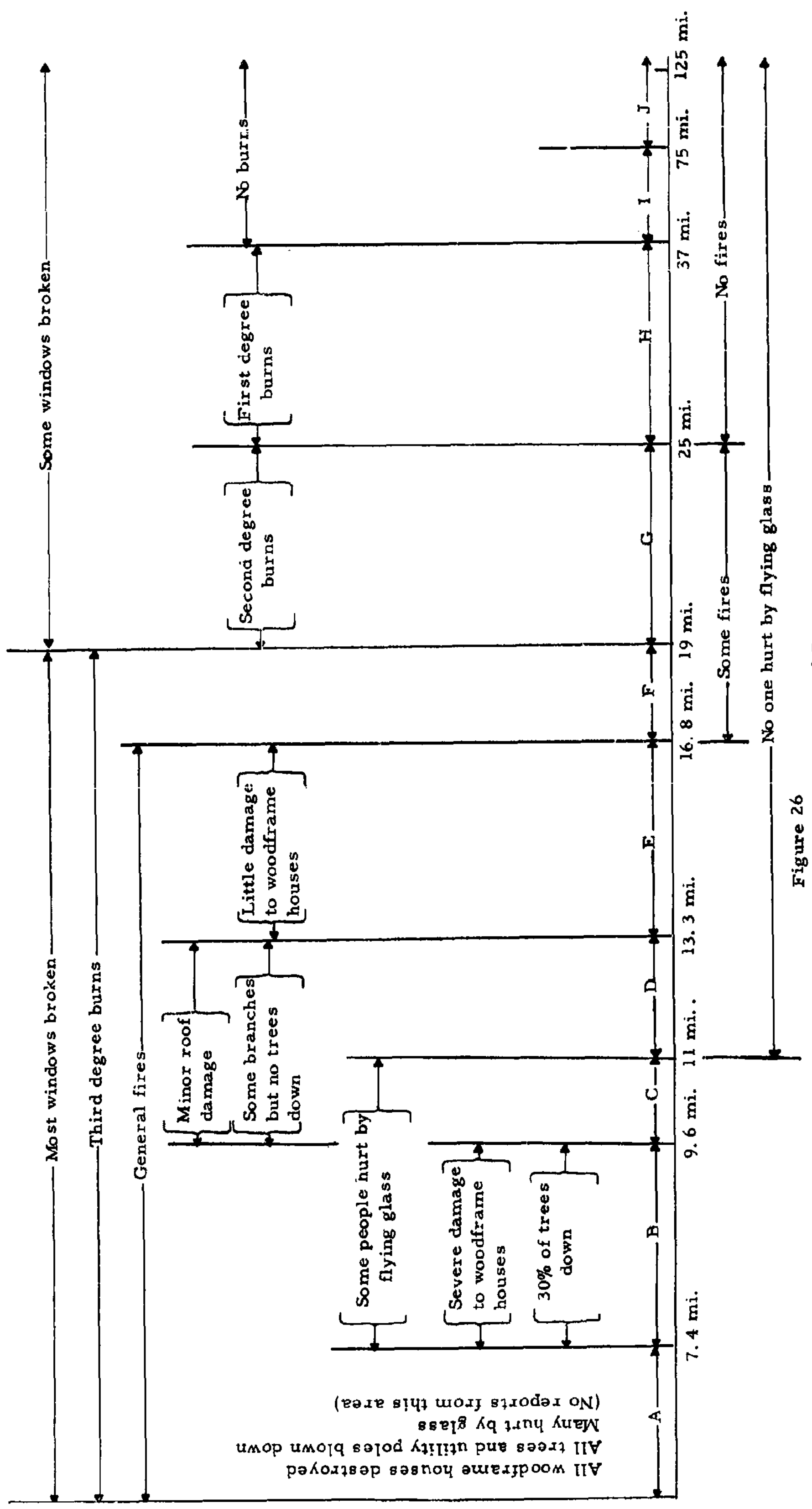


Figure 26
Damage-Range Profile--13 Megaton Ground Burst

4) <u>Formulation of a Set of Messages for Each Weapon Size</u>

As a final aid in generating the messages associated with each bomb, a templet was constructed for each weapon size similar to that shown in Figure 27 for the 13 megaton burst. In the example cited the damage rings "A" through "I" are taken from the bomb profile shown in Figure 26 for the 13 megaton burst.

In addition to the damage rings the templet is divided into eight pie-shaped slices labeled (1) through (8) with (1) coinciding with the north, (2) with northeast, etc. Each of the eight divisions cover 45° with the (1) slice covering $\pm$ 22-1/2° of true north, (2) covering $\pm$ 22-1/2° of true northeast, etc. These divisions provide the means for including sightings of the direction of ground zero as part of each message, and simulate the inaccuracies inherent in initial data concerning an attack. The templet shown in Figure 27 is now divided into 80 segments. If it is assumed that a 13 megaton bomb has exploded at the center, a person located in any of the 80 segments might be expected to observe a distinct set of events relative to the explosion. For example, a person located in segment "1-C" might report sighting the explosion in the south (i. e., due south $\pm$ 22-1/2°) and report such damage as third degree burns, most windows broken, some people cut by glass, etc. A person located in segment "4-G" would report sighting the explosion in the northwest (northwest $\pm$ 22-1/2°) and would observe such things as second degree burns and some fires. Appendix B of a separate technical memorandum entitled "Operational Test for the Damage Assessment Function of State and Regional Civil Defense Control Centers", submitted to the Office of Civil Defense November 28, 1962 lists the eighty messages associated with this bomb as well as the sets of messages associated with the other seven bombs listed in Table 6. An examination of Appendices A and B in this separate technical memorandum shows that not all the information associated with a particular segment is given in the message associated with that segment, nor are messages worded in any particular way. For example, some are made to appear as if they originate from trained observers, others are written as though they came from persons in a frightened or hysterical state. Each message is preceded by an identification of the weapon yield and type and the segment reporting. In addition, a blank space is provided for the actual name of the town reporting this message. The means for assigning the name of a real town to each message is described in the next section. For example, the message from segment "1-C" for a 13 megaton ground burst appears as:

13 MEGATON GROUND BURST SEGMENT 1-C

This message originates from________________________

Gigantic flash to the south. Windows shattered. Many fires. People badly burned. People bleeding from cuts. Roads covered with litter. Send help.

The message from "4-G" appears as:

13 MEGATON GROUND BURST SEGMENT 4-G

This message originates from________________________

Bright flash northwest of here. Some small fires started but otherwise no damage. Many burned by flash. Mostly first and second degree burns.

Part 3 presents a step-by-step procedure for actually using these messages in a test to measure the ability of a control center to perform the damage assessment function.

3. How to Set Up and Administer the Test

This section presents the step-by-step procedure for setting up and administering a test for a control center.

a. The Test Administrator must obtain a set of maps covering the control center's area of interest. A set of automotive service station maps will suffice although maps having a smaller scale are preferable. The only critical requirement is that all the maps be of the same scale.

b. Using the damage profiles in Appendix A of the separate technical memorandum described on Page 89 the Test Administrator must construct a templet, similar to the damage and sighting templet in Figure 27 for each of the eight weapon sizes. However, these templets must be made of clear plastic and to a scale identical with that of the maps described in Step 1. The damage rings radiating out from the central points, the lines dividing the templet into eight pie-shaped segments, as well as the identification numbers and letters and north arrow can be applied to the plastic using an India ink pen.

c. A number of these templets are now spotted on the area maps in whatever manner suits the Test Administrator. The location and characteristics of each weapon used are recorded for use later in

evaluating the degree to which the control center was able to determine these parameters. The only requirement is that the north arrow of each templet be oriented to match north on the map. The location of ground zero on each templet should be related to probable target areas. However, it is strongly recommended that weapons not be detonated precisely over "well known" target areas such as SAC bases, industrial or population complexes, etc. Such a procedure tends to discourage control center personnel from guessing at the location of ground zero and yield on the basis of where they think the likely targets are.

Not all eight weapon sizes need be used in any particular test. Limited experience with this technique indicates that three to five weapons in a 250,000 square mile area (500 x 500 miles) is a reasonable exercise. However, these numbers may be varied to any degree desired at the discretion of the Test Administrator.

In addition, the same weapons can be used more than once in a particular test. This simply involves making more than one templet for the particular bomb.

Finally, it is perfectly acceptable to locate the ground zero points so that two or more templets overlap. However, this procedure makes the test more difficult for the control center and should only be used as training improves. If this technique is used, it is necessary to make some changes in messages originating from points within the overlap area. These changes are outlined in Table 9 for the situation where the templets of two bombs overlap.

Rules handling the situation where three or more templets overlap can be developed in a similar manner.

d. With the chosen templets spotted over the area map, each segment is examined to determine if a town or facility falls within its boundaries and if there might exist in this location the means for reporting bomb sightings and damage estimates to the control center. In the experiments with this test that have been run to date it has been assumed that any town or military facility would have the means of reporting such data. Only one such reporting station within each segment is chosen. The code number of each segment is then used to identify the corresponding message located in Appendix B of the separate technical memorandum described on page 89. If, for example, such a templet were made of the 13 megaton bomb described previously, and it were positioned over a map, the segment "4-G" might enclose the town of "Central City." If this were the case the name "Central City" would then be written into the

appropriate spot on the message. Some of the messages contain information such as "An explosion has taken place in the direction of ______________________." If such a message is used the Test Administrator should pick a large city, or a well-known geographical location, which might well have been used as a reference by the reporting station sending this message, and fill in the blank with the appropriate information.

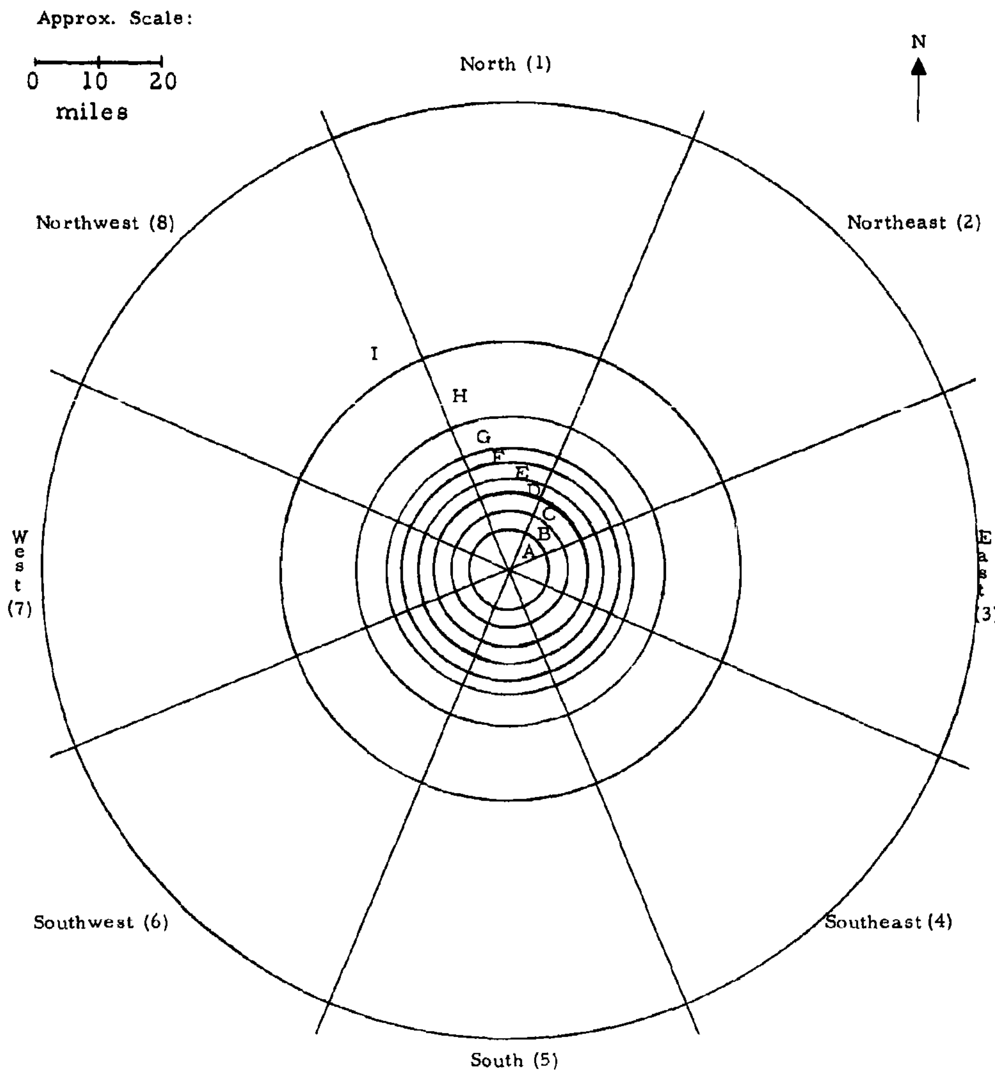


Figure 27. Damage and Sighting Templet for 13 Megaton Ground Burst

Table 9

Procedures for Changing Messages
In Areas Where Two Templets Overlap

	Overlapping segments where damage is more severe from Bomb A than Bomb B	Overlapping segments where damage is more severe from Bomb B than Bomb A
Bomb A explodes first	1. No change in Bomb A messages. 2. Delete all reference to damage associated with B segment so that the message only contains data pertaining to the direction of ground zero.	1. No change in Bomb A messages. 2. No change in Bomb B message.
Bomb B explodes first	1. No change in Bomb A messages. 2. No change in Bomb B messages.	1. Delete all reference to damage associated with the A segment so that the message only contains data pertaining to the direction of ground zero. 2. No change in Bomb B message.

Not all segments enclose a town or possible reporting point. This is perfectly all right and is handled by simply not using the messages associated with these segments.

Experience to date indicates that as few as 20% of the messages provided for each weapon are sufficient to determine the size and location of a bomb. It is believed that 30% to 40% of the total messages for each weapon should prove sufficient to make the necessary estimates.

Following the entry of town or facility names on messages related to certain of the templet segments of each bomb, the actual bomb size and segment code number appearing at the top of the chosen messages are clipped off and destroyed. In the cases cited on pages 93 and 94, the notation "13 megaton ground burst segment 1-C" and "13 megaton ground burst segment 4-G" are clipped off and destroyed. This procedure then "personalizes" a group of messages that are fed to the control center in order to test their ability to locate points of ground zero and estimate the various weapon yields.

e. The next step is for the Test Administrator to select a means and time sequence for sending these messages to the control center. The simplest method is to use the messages clipped out of a separate technical memorandum entitled: "Operational Test for the Damage Assessment Function of State and Regional Civil Defense Control Centers," submitted to the Office of Civil Defense November 28, 1962. Another technique is to have a typist copy this group of messages (including the town or origin) on separate cards. These messages are thoroughly mixed* and are handed to the control center a few (three to five) at a time. The frequency with which these messages are fed to the center is not critical. However, the rate should be rapid enough to insure the continued action of the people being tested. A test involving 100 messages should take no more than two hours. A somewhat more realistic method of transmitting data entails putting the messages on a teletype tape. The tape is fed into a receiver located in the control center. The messages are taken from the receiver and those appropriate to the test are given to the damage assessment personnel. The tape, of course, can be used again. Similarly, radio and telephones can also be used. These techniques are considerably more elaborate and while they add somewhat to the realism of the test they are by no means critical.

*In the case where templets of two or more bombs overlap some modification of messages in the overlapping areas may have to be made as described on page 97.

f. In order to obtain maximum benefits from this test, it is necessary to brief the pertinent control center personnel concerning the purpose of the test, the nature of the messages they can expect to receive, the estimates expected of them (i. e., ground zero, weapon yield, and ground or air burst), and the kind of knowledge they will use to make the estimates. The importance of this last point cannot be overemphasized. No test of this kind will have any value unless those persons being tested have a thorough knowledge of nuclear weapons' effects. For example, it is essential that any one taking this test be able to convert measurements of heat (cal/sq.cm.) and pressure (psi) as recorded at varying distances from a nuclear explosion, to detonation altitude and weapon yield. "The Effects of Nuclear Weapons," 1962, published by the Atomic Energy Commission, is the best and most easily understandable source of this kind of information. It is also necessary that persons being tested have a familiarity with various techniques for obtaining a fix on a ground zero point from a number of line of sight bearings. Finally, it should be pointed out that each explosion involves either an air or ground burst with detonation occurring at optimum altitudes. While the basic purpose of this test is to evaluate the ability of control center personnel to estimate initial ground zero and weapon yield data as soon as possible after an attack, it will also prove of value as a teaching device. Preliminary experiments indicate that a subject's general knowledge about the effects of nuclear weapons as well as his ability to use these data correctly in estimating ground zero and weapon yield increases markedly following even one test run. This is an important byproduct of the test, since the ultimate objective of any test should be to improve operator performance. The only special materials necessary in the control center are a set of maps of the area of interest.

4. Scoring

The scoring system for this test must perforce be based on the degree to which estimates of weapon yield and location of ground zero as calculated by control center personnel agree with the "real" values of these parameters as recorded by the test administrator from the particular sets of messages used.* Because of time limitations only a small number of subjects have had an opportunity to take this test. This number was large enough to prove out the workability of the test but insufficient to generate enough data to permit the formation of a scale against which

* The determination of whether a detonation is an air or ground burst is an integral part of the calculation of weapon yield and is therefore not considered as a measure of operator performance.

test results could be measured and evaluated. However, indications are that the accuracy of ground zero and weapon yield calculations should be evaluated separately. In addition, it is believed that the accuracy of ground zero estimates should be measured in terms of the number of miles that separate the estimated ground zero points from the location of the "true" ground zero. The accuracy of weapon yield estimates should be measured as a percentage deviation from the "true" values of weapon yield. When the test is used a sufficient number of times with a large number of damage assessment groups, a suitable quantity of data concerning operator performance will be accumulated. These data can then be used to compare individual group performance with the mean of all groups.

5. <u>The Suitability of the Test With Respect to State and Regional Control Center Requirements</u>

As set forth in Part 2 there are five special features which should be a part of any test designed to measure the ability of state and regional control centers to perform the damage assessment function. The degree to which each of these features have been incorporated in the test just described is outlined below.

a. The test can be given to individual state or regional control centers as well as to groups of such centers, without requiring the participation of outside agencies or special communication networks. This is so because the test packages essentially are self-contained and require no inputs from outside sources.

b. The test can be administered repeatedly to the same personnel without decreasing its value as a measure of their performance. There are two reasons for this. First, the names of towns associated with each message passed to a control center change each time the test is given, i. e., when the ground zero points associated with each bomb are shifted. Secondly, only a random 20% to 40% of the messages associated with each bomb are used in any particular test. As a result, the chances of control center personnel "recognizing" any particular message as being associated with any particular bomb are remote.

c. Once the test is used a sufficient number of times to permit the accumulation of a suitable quantity of data concerning operator performance, a scale can be developed against which test results can be measured. The use of such a scale will make it clear which groups or individuals require additional training. Specific deficiencies, i. e., insufficient knowledge of the effects of nuclear weapons, etc., can then

easily be determined by questioning an individual with respect to the method he used to determine values of ground zero and weapon yield.

d. The test requires a relatively small amount of time to set up, administer and score. For example, assuming that four weapons are to be used in a test, the spotting of weapons and selection of messages by the test administrator prior to a test should take no more than two hours. The briefing given by the test administrator to a control center group prior to a test takes about 20 minutes. The actual test itself where messages are fed to control center personnel for the purpose of estimating ground zero and weapon yield should take no more than two hours. Finally, the scoring of test results should take very little time. The amount of time required here is not considered prohibitive.

e. There is no requirement for special equipment (other than the normal area maps present in any state or regional control center) or training for control center personnel prior to a test.

It is, of course, impossible to measure quantitatively the degree to which this test incorporates these features. However, it appears reasonable to state that the test described in this section meets these requirements to a satisfactory degree.

III. A PROPOSED APPROACH FOR AN ANALYSIS OF THE CIVIL DEFENSE SYSTEM, DESIGNED TO PROVIDE A DETAILED DEFINITION AND LOGICAL JUSTIFICATION OF THE FUNCTIONS OF CIVIL DEFENSE AND THE COMPONENT ACTIVITIES ASSOCIATED WITH EACH FUNCTION

This chapter of the report contains the formulation of the system analysis prepared during the latter phase of the contract. The general objective of this analysis is the quantitative definition of the functions and the component activities of each function of the civil defense system designed to maximize civilian survival from a nuclear attack. This section of the report will be divided into three parts. The first part will discuss the over-all problem in some detail. It is convenient to consider the civil defense system in terms of two time periods; therefore, the second part of this section contains the methodological approach of the analysis for the attack and shelter stay period, while the third part is devoted to the methodological approach for the post shelter period.

A. The Problem

The proposed analysis is basic to the general problem area of testing civil defense plans at the local, state, and federal command levels. It is not possible to develop test methodology for other than broad functions until it is known in some detail precisely what are the functions and component activities of the civil defense system. Thus, this approach is specifically directed towards defining and justifying these functions and component activities. Once specific civil defense activities have been defined to the satisfaction of all, then it follows that detailed plans can be developed, methodology for testing plans can be developed, and the necessary training program can be developed. However, until activities have been logically defined and justified, all civil defense planning, testing, and training must contain a large element of speculation. A system analysis leading to activity definition will not totally eliminate speculation but it is hoped that the results of such an analysis will at least reduce the speculative element in the necessary decisions.

It is convenient to express the general problem of defining civil defense system activities in terms of a number of component subproblems. The remaining portion of this section will be devoted to discussing these subproblems.

1. The problem of budgetary limitations

The fact that budgetary limitations do exist is, of course, commonplace. Considerable work has been done in the past to estimate the cost of civil defense systems. This effort has led to estimates of the cost of basically two kinds of systems, either a minimal system costing relatively little or a "splendid" system which is quite expensive. It is possible (perhaps even probable) that the funds made available to civil defense are less than those required for the splendid system. On the other hand, the funds may be somewhat more generous than those required by the minimal systems. If this were the case, how should the money be spent? However, more importantly, at least from the viewpoint of this research program, how will the activities within the civil defense system be changed by the money made available for expenditure? Since it is believed that the civil defense system as finally designed will be influenced by funding, anticipated funding will be treated parametrically. This means that the methodology will be concerned with the kinds of civil defense system activities which will maximize civilian survival for a number of different funding levels. This will not only help to define activities but will have the important side benefit of suggesting the value of additional funding in terms of increased civilian survival. To summarize briefly, what is being proposed here is that the analysis start with a level of funding and be concerned with the optimum system design for that funding level rather than designing a system and then estimating its cost.

2. The problem of enemy attack options

The enemy has certain attack options, and it is impossible to predict which options might be selected. (Incidentally, it is implicitly assumed here that the attack options have or can be defined.) If the enemy's actions could be predicted with certainty, then the problems of civil defense would be somewhat simplified. Even placing a probability on the various options would help. It is believed, however, that associating a probability with enemy actions is always dangerous. First, it is doubtful that meaningful probabilities can be established without the cooperation of the enemy's general staff. Second, if probabilities were known, the actions taken as a result of this knowledge would cause them to change. Thus, it is concluded that attempting to predict enemy action, expressing the prediction probabilistically, and utilizing the probability is essentially chasing a "will-o'-the-wisp." However, the fact that the enemy does have attack options cannot be ignored. Moreover, it is possible that placing certain probabilities on enemy courses of action will be unavoidable.

It is planned in this analysis to treat the enemy attack options somewhat parametrically. There has been a fair number of attacks theoretically launched against the continental United States. It is planned to subject civil defense systems developed for each funding level to the various attacks that have been postulated and worked out in detail. It is anticipated that the actual selection of a civil defense system in terms of its capability to enhance survival against the various attacks will be to some extent a matter of judgment; judgment guided by the basic underlying philosophy of minimizing the damage inflictable by the enemy. However, it is possible that for a given level of funding the civil defense system which maximizes survival may be largely insensitive to the enemy attack options or, at most, only the design of certain subsystems would be influenced by the kind of attack.

3. The problem of survival activities and support activities

It is important to recognize that the threats to civilian survival and the threats to the social-economic system do not occur simultaneously. It is of little importance to provide for the survival of fallout only to have the survivors perish of thirst, hunger, etc. The important point is, of course, that civil defense system activities must be concerned not only with surviving a threat but also with civilian survival from the time of attack until that time when the remaining population can subsist on the rebuilt economy. Survival over time has long been considered by the federal government, and certain survival functions have been delegated to most of the departments and agencies of the government. Furthermore, the designated departments and agencies have been developing systems to perform their function in the over-all survival of the nation.

Because certain survival functions have been delegated to the Office of Civil Defense while certain others have been assigned to other government agencies, it is important to realize that some activities of the civil defense system will be directly related to civilian survival while others will be primarily for the support of the activities of other departments and agencies.

In this analysis, time can be meaningfully divided into two periods. The first time period is defined as starting with the attack and terminating when fallout is no longer a serious threat to human life in a particular location. It is during this time period that the responsibility for civilian survival rests largely with the civil defense system, and the activities of the system must be so tailored.

The second time period is defined as that time from when fallout ceases to be a threat in any particular location to when the surviving population can exist on the goods and services provided by a rebuilt economy. It is during this second time period that the activities of the civil defense system will be devoted to supporting the activities of the other departments and agencies of the federal, state, and local governments. However, it is important to realize that means for performing the civil defense function during the second time period are not independent of what was done during the first time period.

Utilizing two distinct time periods is considered basic to this study and the research methodology to be discussed later in the section is presented in terms of each time period.

4. The problem of different shelter systems

Shelter is the only known practical defense against the effects of a nuclear attack. Therefore, the civil defense system must be developed with shelter as the principal means of protection. However, there are different kinds of shelter systems that can be developed, each system costing a different amount of money and each system providing different degrees of protection. It is proposed in this chapter to consider three kinds of shelter systems. These systems are:

a. A shelter system where the shelters provide only protection against fallout. This represents essentially the system being currently developed by marking shelters in existing structures or upgrading the protection factors of shelters in existing structures.

b. A shelter system where the shelters provide protection against fallout, secondary fires,* and accidental fires.** The shelter in this system attains fire protection primarily through isolation from surrounding structures.

*The term secondary fires is used to mean fires which start by spreading from the primary fires which, in turn, are started by the thermal radiation from a nuclear explosion.

**The term accidental fire is used to mean fires that start as a result of normal household accidents but reach serious proportions because the sheltered population is unable to combat these fires.

c. A shelter system where the shelters provide protection against fallout, fires, and blast. It is recognized that this kind of shelter may not be appropriate in most rural areas but primarily in the metropolitan areas. It is further recognized that a specific overpressure must be selected to define a blast shelter. The selection of the overpressure has not as yet been made and it may be desirable to consider more than one overpressure.

As will be seen from the discussion in the methodological portion (Part B) of this chapter, the three shelter systems described above will be considered independently in this study. The study will be concerned in part with determining for a given level of funds which of the preceding shelter systems should be selected. The proposed methods for doing this are also discussed in Part B of this chapter.

5. <u>The problem of shelter support systems</u>

Having accepted the fact that the shelter system is the principal means of protecting the civilian population, it is to be recognized that life must be sustained in the shelter. Sustaining life in the shelter is the function of what in this paper are termed the shelter support systems. The shelter support systems to be considered in this study perform the following functions deemed vital to survival.

a. Ventilation. This is the system which supplies air and circulates it in the shelter to avoid suffocation and overheating.

b. Food. This is providing the shelter with sufficient food to avoid starvation or the early emergence in search of food.

c. Water. This is providing the shelter with sufficient water to avoid death from thirst or forcing shelterees to emerge from the shelter in search of water and die as a result of radiation.

d. Sanitation facilities. This is providing the means for shelter sanitation to avoid death from disease.

e. Radiation monitoring. This is providing the shelter with the capability of measuring local radiation to avoid too early emergence, to permit emergence as soon as possible, or to avoid spots of intense radiation within the shelter.

Each of the shelter systems described previously will require its five shelter support systems. However, the form of the support system and hence its component activities may be different for each shelter system. Furthermore, the allocation of funds between shelter systems and support systems may be different for different funding levels. The methodology for introducing the shelter support systems into the study will be discussed in Part B of this chapter.

6. The problem of support systems for other governmental activities

It was mentioned in preceding paragraphs of this section that part of the activities of the civil defense system must be concerned with supporting other government agencies and departments which have been assigned survival functions. This appears to be particularly true for the time period starting with shelter emergence.

The responsibility of developing and operating certain systems has been specifically assigned to the Office of Civil Defense in the Executive Orders of the President. The systems, so assigned, which appear to be more for the support of the other agencies of the government are:

a. Nationwide radiation monitoring system

b. Communications system

c. Damage assessment system

The problem as seen from the point of view of this study is: (1) to determine the requirements imposed upon these systems if they are to provide the necessary support to other government agencies; and (2) given the operational requirements of the system, to determine what activities must constitute the system to meet the requirements. The proposed methodology to treat the problem of intragovernmental support is discussed in Part C.

It might be noted in closing that the support systems considered in this section are not totally independent of the shelter support systems. For example, radiation monitoring and communications are of value to a shelter system. However, in this study these systems will be approached as primarily in support of other agencies with the ancillary benefit of supporting the shelter system.

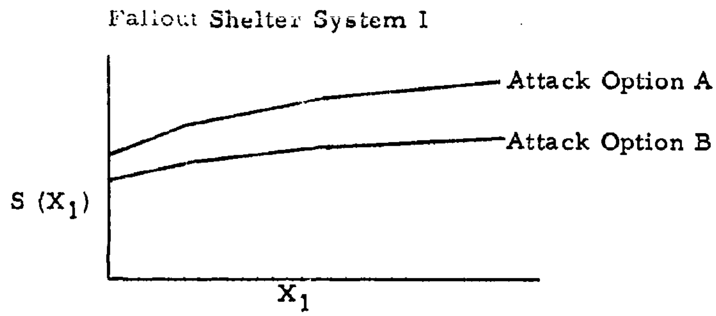
B. Methodological Approach--Attack and Shelter Stay Period

The preceding portion of this chapter was devoted to identifying the kinds of problems that must be considered in determining the activities of the civil defense system. The purpose of Part B is to describe the methodological approach, as seen at this time, to solving these problems. The basic theme of this approach can be expressed rather simply as follows: for a given funding level, what activities should be included in the civil defense system to cause maximum civilian survival after a nuclear attack not neglecting the fact that there are a number of different attack options available to the enemy?

The methodological approach to be described here will consider each of the three shelter systems separately and explore the effect on each of various enemy attack options. For illustrative purposes, only one shelter system will be presented in this paper, but it is clear that the methodology used can be applied to each shelter system. It will be noted that in each step in the procedure described below, nothing is said about funding levels. The method of combining each step for a given funding level will be discussed later.

1. Survival of shelter spaces

The term "survival" is used here to mean the number of shelter spaces with a predetermined protection factor (e. g., 100) that actually survive the blast from a nuclear attack. The actual number that survive will be functionally related to the enemy attack option and also related to the total number that exist. The total number that exist is in turn related to the amount of money that is spent on shelter marking or shelter construction. In the case of shelter system I the expense is primarily incurred in surveying and marking existing structures. The functional relationship desired is illustrated by the following diagram.



where: $S(X_1)$ is the number of shelter spaces in shelter system I that survives the blast and the fireball.

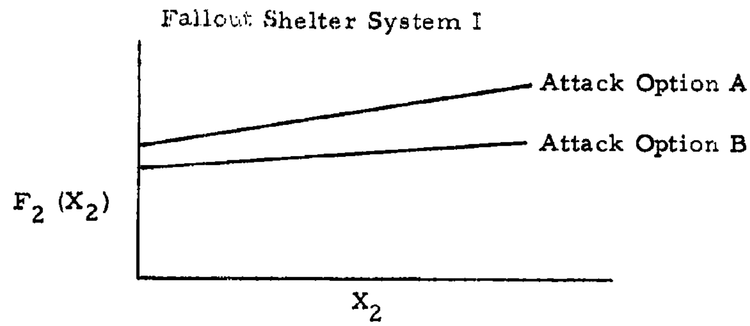
X_1 is the dollars expended in developing shelters which, for system I, consists of surveying, marking, and upgrading existing structures.

It is assumed in the functional relationship $S(X_1)$ that shelters will not be located in areas where a detonation is unlikely but rather will be located as conveniently as possible to the civilian population, and hence are likely to be in or close to target areas. Shelter system I essentially represents the current shelter system and a certain amount of funds has already been expended. Thus, X_1 is to be thought of as the expenditure of additional funds to survey and mark additional shelter spaces, upgrade the protection factor of surveyed shelters, or incorporate shelters in new structures. If all shelter spaces have been surveyed and marked, then the functional relationship between surviving shelter spaces and the expenditure of additional funds, X_1, will be a straight line parallel to the abscissa. It will be noted that only two attack options, A and B, are shown in the preceding figure. The methodology is not limited, however, to considering only two options.

2. Shelter spaces occupied

The number of shelter spaces surviving the initial effects of the attack is of little interest except when shelter spaces are occupied. The next relationship to be considered is how shelter occupancy is influenced by the expenditure of funds. The following diagram is presented in terms of the fraction of shelter spaces occupied as a function of money spent on a civilian warning system. It is recognized that perhaps more than a warning system is required to insure shelter occupancy (e.g., traffic control). If other such factors can be identified they will be incorporated into this curve. However, for purposes of illustration it will be assumed that shelter occupancy is functionally related only to the funds expended on the warning system.

Again, this figure is presented only in terms of shelter system I and two attack options. A similar relationship is to be developed for shelter systems II and III as well as more than two attack options.



where: F_2 (X_2) is the fraction of shelter spaces marked that are actually occupied.

X_2 is the dollars expended on the civilian warning system.

A certain amount of money has already been expended on the warning systems, and X_1 is thought of as additional expenditure. The fraction of shelter spaces occupied as a result of the existing warning system is shown by the value of $F_2(X_2)$ for X_2 equal to zero.

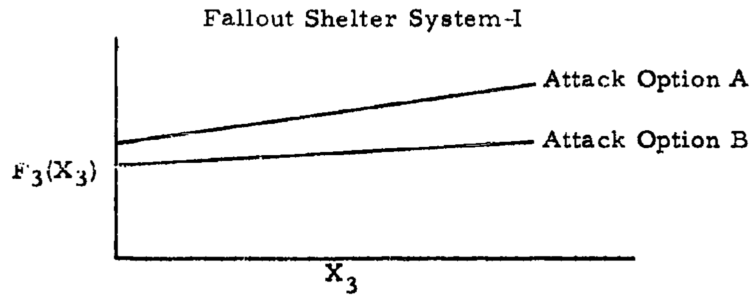
The product S (X_1) F_2 (X_2) represents the number of occupied shelter spaces that survive the initial effects of the attack.

3. Shelter spaces surviving fire

It is to be anticipated that the thermal energy from the explosions will set a large number of fires. It is to be further expected that these fires will spread and consume a certain number of shelters. Hence, it is not sufficient for survival to occupy a shelter space that has survived blast and the fireball. It is also necessary that the shelter space survive the secondary fires caused by the explosions, as well as accidental fires.

The fraction of occupied shelter spaces surviving fire depends upon: (a) which shelter system is adopted, and (b) what measures are taken to control fires.

It is believed that a meaningful relationship, as shown in the following diagram, can be developed for each shelter system and attack option.



where: $F_3(X_3)$ is the fraction of shelter spaces surviving the fires resulting from the attack.

X_3 is the dollars expended on a system for controlling fires.

Determining how money spent on a system for controlling fire influences the number of shelter spaces that survive the fires is considered to be one of the more difficult parts of this research effort. OCD has funded a large fire research program and it is anticipated that the required functional relationships will depend heavily upon the results of this research program. The intercept of $F_3(X_3)$ represents the fraction of shelter spaces of Shelter System I that can be expected to survive fires if no money is expended on a fire control system.

The number of occupied shelter spaces that can be expected to survive blast, fireball, and the secondary and accidental fires associated with a given attack can now be expressed as:

$$S\ (X_1)\ F_2\ (X_2)\ F_3\ (X_3)$$

4. The shelter support system

It was stressed earlier that the civil defense system must be capable of meeting a number of threats and that these threats would occur over time. Up to this point survival has been considered in terms of surviving the initial effects of the attack and the fallout and fire resulting from the attack. The next part of this chapter will be concerned with what has been termed the shelter support systems.

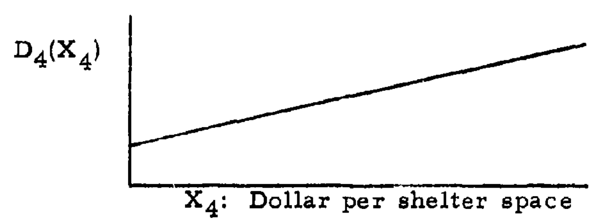
Each of the shelter support systems is designed to combat a given threat to life in the shelter. The position adopted in this analysis is that the allocation of funds to each shelter support system causes the shelter to avoid

a threat to survival for a given length of time. For example, if no funds were spent on sanitation equipment, the shelter system would be habitable for a certain length of time after which the disease and discomfort generated from human waste would begin to be a serious threat to the shelterees. Expending funds on sanitation equipment extends the period of time before disease becomes a threat or the shelterees can no longer tolerate their condition. If no funds are spent on food, the shelter population would exist for a certain length of time before faced with the choice of starvation or risking exposure to radiation. The expenditure of funds in providing food for the shelter can then be thought of as extending the period of time before hunger becomes a problem. This same reasoning can be applied to the other shelter support systems. It is to be anticipated that the functional relationships between the number of days a shelter can be occupied and the funds expended on the shelter support system will differ significantly for each support system considered.

The first step in introducing the shelter support systems into the analysis is to develop functional relationships expressing the number of days that a sheltered population will avoid a threat and the amount of money spent on the system designed to combat the threat. The relationships will now be briefly discussed.

a. The ventilation system

The number of days that a shelter system remains habitable as a function of the money expended on providing a ventilating system might appear as shown in the following diagram.



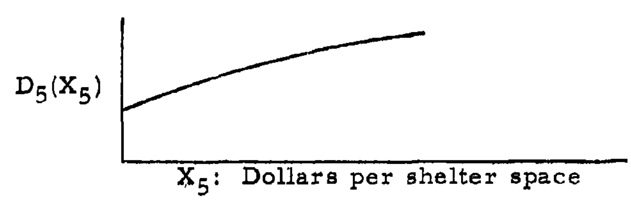
where: $D_4(X_4)$ represents the number of days the average shelter in Shelter System I remains habitable.

X_4 is the cost of equipping shelters with ventilation equipment expressed as dollars per shelter space.

There are certain features of the preceding figure that require some explanation. It will be noted, first of all, that this relationship is independent of enemy attack option. It is believed that such independence is a reasonable assumption. It will also be noted that the curve provided here is a straight line with a constant slope. This, of course, may be totally erroneous since it may well turn out that the relationship is a step function indicating that all shelters in the system must be provided with ventilation systems before the shelters can be considered habitable for any length of time. This would be true of underground shelters, but perhaps not of shelters in existing buildings. Once shelters have been equipped with ventilation systems, it is likely that further expenditures of funds will be limited to fuel supplies, etc., and perhaps rather insensitive to the number of days the shelter remains inhabitable. One other point might be mentioned, which is the possible independence of this relationship among shelter systems. This appears to be a reasonable assumption but, of course, must be verified.

b. The food system

A shelter which is not stocked with food can be inhabited for a certain length of time, and as funds are expended on stocking shelters the number of days during which the threat of hunger is avoided is increased. What is required then is a relationship as illustrated by the following diagram.



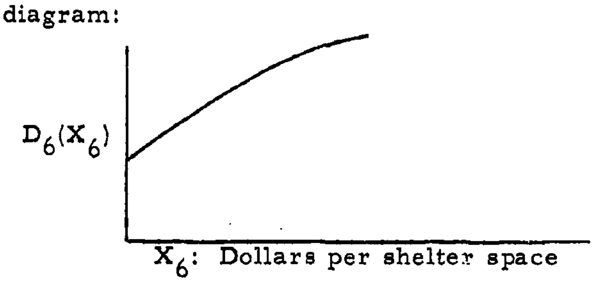
where: $D_5(X_5)$ represents the number of days shelter occupants will avoid the threat of hunger.

X_5 is the amount of money spent on stocking shelters with food expressed as dollars per shelter space.

The intercept of the preceding figure shows the average number of days that shelter occupants can be expected to remain in the shelters.

c. The water system

If shelters are not stocked with water, it is to be expected that the shelter occupants can remain in the shelter for some finite period of time. This time period can be extended if means are provided to use existing water supplies such as boilers, pipes, etc., to be found at least in existing structures. It can be further extended by provision of special supplies of water. The relationship required can be illustrated by the following diagram:

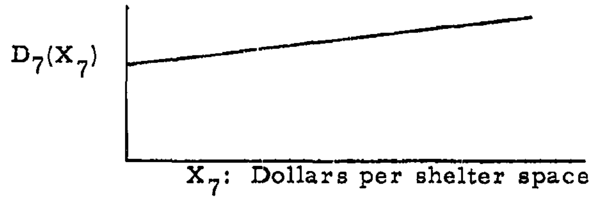


where: $D_6(X_6)$ represents the number of days shelter occupants avoid the threat of thirst.

X_6 is the funds expended on stocking shelters with water expressed in terms of dollars per shelter space.

d. The sanitation system

A shelter will remain habitable for a certain period of time if no sanitation facilities are provided. However, there is some point where human waste matter becomes a threat to life, either directly or by driving the occupant out into a radiation hazard. The number of days that a shelter can be occupied before this threat becomes serious is dependent upon the funds expended on sanitation facilities within the shelter system. A functional relationship as shown in the following diagram is required.



where: $D_7(X_7)$ is the number of days shelter occupants avoid the threat of disease caused by human waste.

X_7 is the dollars spent on shelter sanitary facilities expressed as dollars per shelter space.

It is believed that the foregoing illustrations are sufficient for purposes of the analytical procedure being discussed. However, there are other items in the civil defense system which can be considered as shelter support systems which are not included here. Some of these items are:

1) Shelter managers.

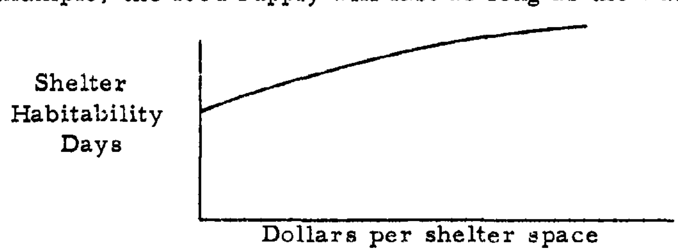
2) Shelter radiation monitoring equipment.

3) Shelter medical supplies.

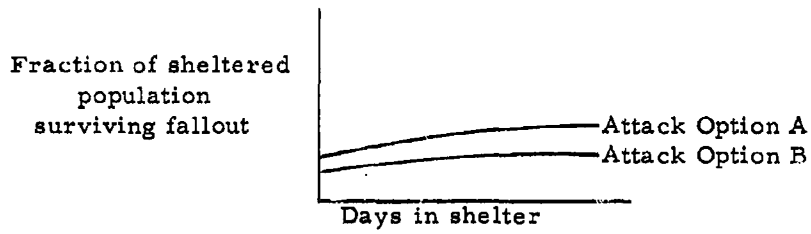
4) Shelter communications equipment.

Each of these items in some way seems to extend the time period that the civilian population can and/or will remain in the shelter. Furthermore, each of these items requires a certain amount of funds to obtain for the shelter system. Hence it appears, at least intuitively, that a relationship should exist between the number of days a shelter's habitability is extended by shelter managers, etc., and the cost of providing these items. If such cost relationships can be developed, they will be incorporated into the analysis by the methodology to be discussed. However, if meaningful relationships cannot be developed, it is proposed to ignore them in the formal analysis and qualitatively introduce them after the quantitative analysis has been completed.

At this point it is believed that sufficient relationships between days of shelter habitability and funds spent on shelter support systems have been presented for illustrative purposes and the discussion can turn to the utilization of these relationships. The shelter support system relationships are first combined to form an aggregate relationship illustrated by the following figures in which each system is balanced, in the sense that, for example, the food supply will last as long as the water supply.

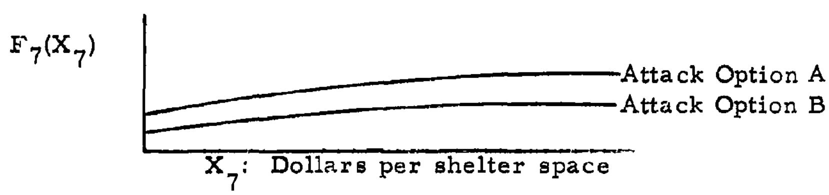


The next functional relation required is that between the fraction of sheltered population that will survive fallout and the number of days that the population remains in the shelter. This is obviously not independent of the enemy attack options and is illustrated by the following figure for two such options.



The intercepts of these curves represent that part of the population which was not threatened by fallout.

The two preceding relationships are now combined to form the fraction of the sheltered population surviving the fallout as a function of dollars per shelter space expended on shelter support systems. This relationship might look like the following:



where: $F_7(X_7)$ represents the fraction of the sheltered population that survives fallout.

X_7 is the dollars per shelter space expended on shelter support systems.

e. <u>The allocation of funds</u>

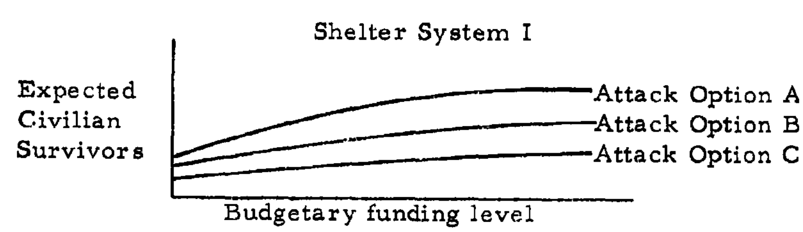
At this point four relationships have been considered which determine the number of civilian survivors as a function of dollars spent on a given shelter system. These relationships are:

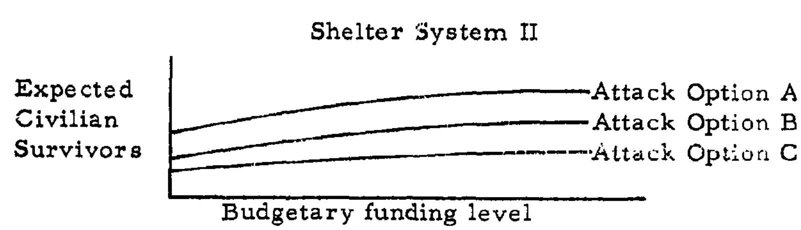
$S(X_1)$	the number of shelter spaces surviving the blast and fireball.
$F_2(X_2)$	the fraction of shelter spaces occupied.
$F_3(X_3)$	the fraction of shelter spaces surviving the fires.
$F_7(X_7)$	the fraction of the sheltered civilian population that survives the fallout.

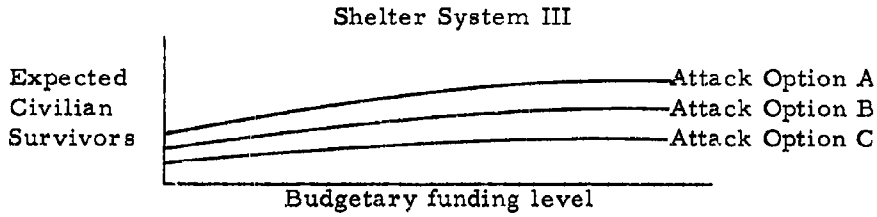
Each of these quantities is expressed in terms of money expended on the civil defense system. The problem remaining is to combine these functional relationships in such a manner that for a given funding level the allocation of funds among these functions will provide for maximum civilian survival. Specific techniques for combining these relations will not be discussed here. It is possible that certain methods of mathematical optimization might prove useful, but if this turns out not to be the case the relationships can always be empirically combined without an excessive computational workload. Although empirical methods offer the disadvantage of providing only an approximate answer, it must be remembered that the relationships themselves will be only approximate.

f. Analytical results of methodology

It is anticipated that the results of the methodology discussed here will result in relationships as illustrated by the following diagrams.







The above three curves are a useful way to present the results of the analysis. However, the question of how funds should be spent and hence the functions and component activities of the civil defense system have not as yet been answered. It was noted in the early part of this chapter that the allocation of funds will to some extent remain a matter of judgment and the preceding diagrams illustrate what this means. If these diagrams show that for a given funding level there is one shelter system and set of component activities that provide a greater number of civilian survivors than any other shelter system, then the selection of a system is straightforward. It is likely, however, that life will not be that simple, although it might. It is to be anticipated that under certain attack options and certain funding levels one system will be paramount, but under other conditions a second system would be selected. If this occurs, then each system can be re-examined to determine if any of its component subsystem can be altered to make it the best system under all attack options. If this does not solve the problem, then the selection of the system must be guided by what are considered to be the more likely attack options during the operational life of the system.

C. Methodological Approach - Post-shelter Period

During the attack and shelter-stay period, civilian survival has been the direct concern of the civil defense system. Those who survived did so because they were in a shelter provided by civil defense, were fed by provisioning done by civil defense, were guided by civil defense trained shelter managers, informed by a civil defense communications system, and so forth. However, when the surviving civilian population can emerge from the shelter for significant periods of time, it is faced with a different set of problems. This set of problems is concerned with surviving on the resources in being until the economy can be rebuilt to the point where it can produce the necessary goods and services to insure continued survival.

It appears that the major activity directly concerned with survival in the post-shelter period is the managing and distributing of resources, which is not, in the main, a function of the civil defense system. At the federal command level, each Department has been assigned specific functions

of managing and distributing certain categories of resources, whereas at the state and local command levels resource management will apparently be accomplished by personnel of the state and local government with the aid of guidelines developed by the Office of Emergency Planning.

If resource management is taken as the major activity during the post-shelter period and if this activity has been assigned to government departments and agencies other than civil defense, the question arises as to what is expected of the civil defense system during the post-shelter period? The position adopted in this analysis is that the civil defense system will provide a supporting role to the departments and agencies of the federal government, the state governments, and the local governments. The term support is used here to mean providing information to other governmental operating units and performing services at the direction of these units.

One of the first problems that must be resolved then is what information and what services will the various governmental units require of the civil defense system? It would be most convenient to defer answering this question. One could simply wait until all the governmental departments had developed the operating systems required to discharge their responsibilities and then request of them the support information and services required of civil defense. There are at least two reasons why it is believed that this problem cannot be ignored at this time. First, if OCD must await the development of systems by other governmental units before it can develop the necessary support systems, a significant delay will be introduced before a national survival system can be considered fully developed. A second reason of some importance is that the civil defense system designed to enhance survival during the attack shelter-stay period cannot be considered independent of the civil defense system to perform support functions in the post-shelter period. In other words, what is expected of the system in the second period will influence the design of the system to perform its earlier functions. There is one point that perhaps should be clarified which is that the analysis presented in the preceding portion of this chapter did not explicitly consider any interdependence between the survival functions of the civil defense system and the support functions of the post-shelter period. Thus, the preceding analysis could result in a suboptimization and this problem must be recognized. However, this does not invalidate the analytical procedure previously discussed because most of the factors included in it were primarily for survival during the attack-shelter-stay period. When the interdependence between post-shelter functions and the attack-shelter period functions are known, it must be considered in the analysis by methods which must remain unspecified at this time.

The Executive Orders of the President have directed the Office of Civil Defense to develop and operate certain systems. Three of these systems appear to provide what are primarily support functions in the post-shelter period with some usefulness during the shelter period. These systems are:

1. Damage assessment

2. Radiological monitoring

3. Communications

It is proposed to start with these systems in this analysis and develop whatever other support system requirements appear to be within the scope of the special skills and knowledge associated with civil defense. The first problem to be considered then is what operational requirements are imposed upon these three systems if they are to fulfill the support responsibilities demanded of them and then what additional requirements, if any, are imposed upon these systems to meet the needs of civil defense during the attack-shelter period.

It is proposed to start with the governmental agencies and departments which have been assigned survival functions. This requires that the various agencies and their assigned functions be identified. The next step is to contact each agency so identified and attempt to determine the procedures they are developing to meet their responsibilities. It would be helpful if each agency had progressed to the point where they could spell out in detail the operational systems being developed. However, it would be naive to think that such would be the case for all agencies. If the various agencies concerned can explain the general features of the system, it is believed that, in cooperation with the agencies concerned, it is possible to develop a system design in sufficient detail to indicate the support demands on each of the civil defense systems. Organization charts assigning responsibilities are not sufficient for this problem. What is needed here is a diagram showing the sequence of operations in the system, the flow of information in the system, and the informational inputs to the system.

Once the requirements imposed upon the civil defense support system have been established then, and only then, can the potential activities associated with each support system be defined. The term "potential activity" is used here simply because it can be anticipated that many demands for services and information will be imposed upon civil defense, and some means must

be determined to estimate the criticality of each demand. The intended approach here is to consider the degradation to the system being supported if the particular kind of information is not provided. This will require some degree of sophistication in understanding of the system's operation, as well as some measure of the system operation. Specific system measures will not be discussed here, but most systems concerned with resource management are degraded in either operating time, operating accuracy, or both by not receiving support information or support services. The effect of this degradation must in some way be estimated to evaluate the criticality of the potential support activity. If it turns out, of course, that any one support activity can be justified for any one management system, then providing the results of this support activity to other management system costs virtually nothing, hence, its criticality can be ignored.

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